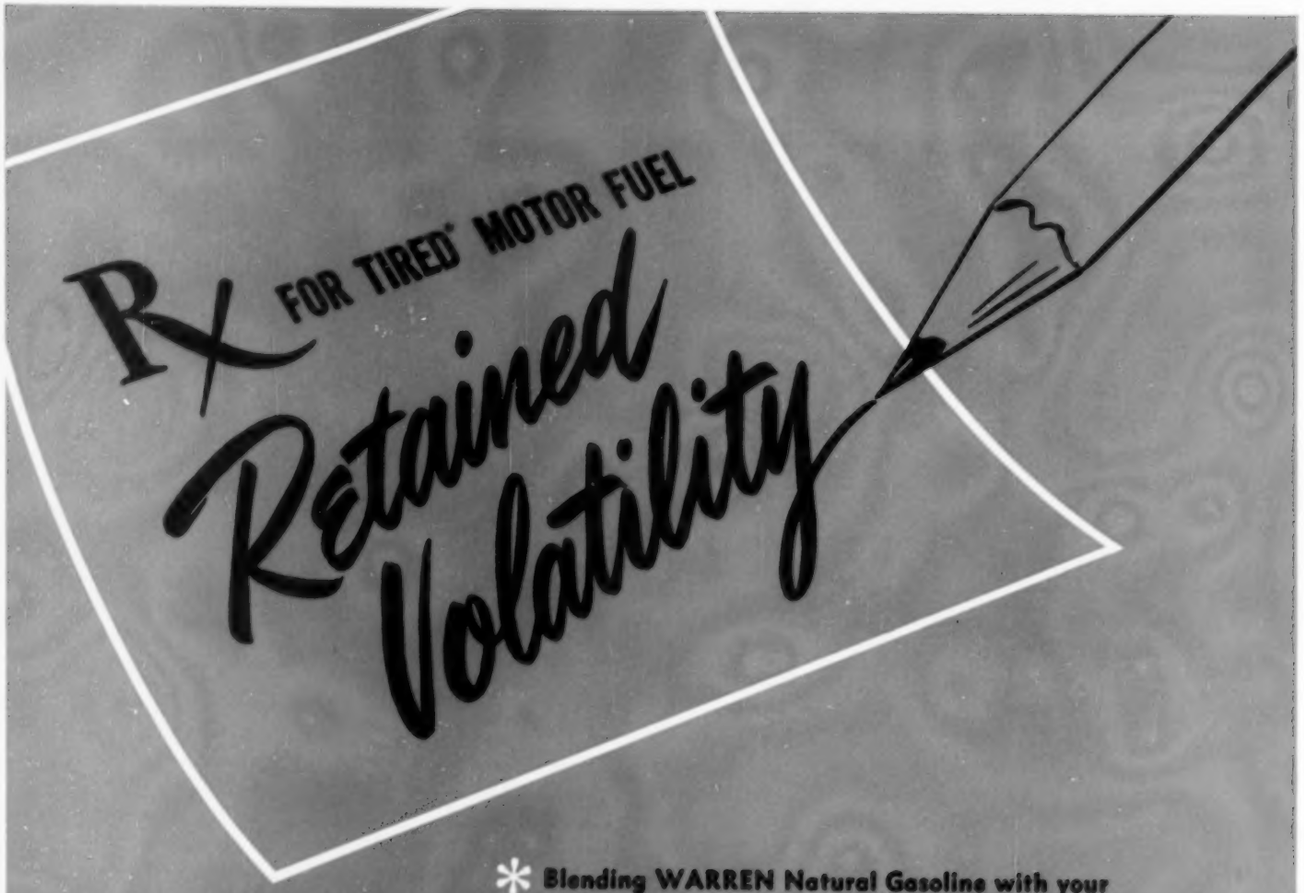
$5 PER YEAR. $1 PER COPY
WORLD PETROLEUM
25TH ANNUAL REFINERY ISSUE
25 YEARS OF SERVICE TO THE INTERNATIONAL PETROLEUM INDUSTRY



* Blending WARREN Natural Gasoline with your present high quality motor fuel will give it the RETAINED VOLATILITY that permanently prevents a "tired" performance after it reaches your customers' fuel tanks. You can always depend on Warren's production, transportation, storage and SERVICE for the grade and quantity of NATURAL GASOLINE you need—when and where you want it.

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PETROLEUM CORPORATION

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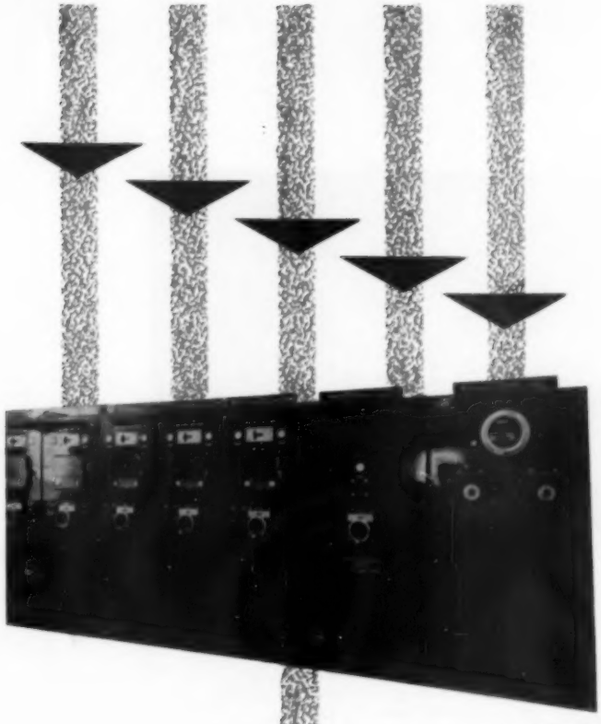


Proportioneers Gasoline Blender control panel with automatic batch cutoff panel at right, for continuously blending famous White Rose petroleum products at rates up to 2,880 barrels per hour.

Proportioneers Loss-In-Weight scale and control panels for adding TEL to finished gasoline in proportion to flow rate.

Stream Blending Produces Finished Gasolines at CANADIAN OIL REFINERIES, LTD.

The Proportioneers Stream Blending System continuously produces finished gasolines at Canadian Oil Refineries, Ltd., Sarnia, Ontario, automatically maintaining preset formulations at all flow rates of finished product. After the gasoline has been blended from straight run, polymer, catalytic, reformate, and butane . . . it is then leaded by Proportioneers Loss-In-Weight TEL Blender.

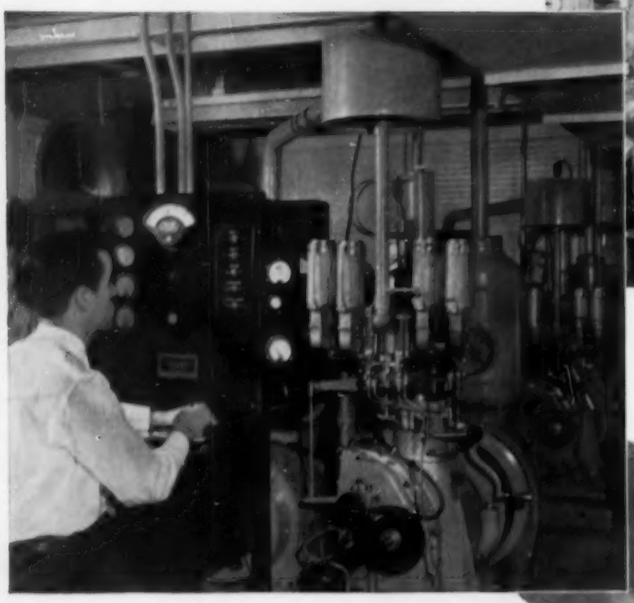
Proportioneers Blending Systems are serving refineries in 17 countries throughout the world. Our experience in the engineering, manufacture, and service of this advanced equipment is at your disposal. Write Proportioneers, Inc., 481 Harris Ave., Providence 1, Rhode Island.

WHITE ROSE

PROPORTIONEERS

DIVISION OF B-I-F INDUSTRIES, INC.

B·I·F METERS FEEDERS CONTROLS



Anybody want an extra laboratory?
We've got *five* of them conveniently located in the major refining areas of the country. They're not exactly "extra" because they do have a purpose—to meet *your* needs. They are staffed and equipped to test products, and handle almost any problem involving the use of additives.

These laboratory facilities are one of the 23 or more helpful services the Du Pont Petroleum Chemicals Division offers you.

On call...

Twenty-three helpful services!

Du Pont's comprehensive services are as close and as handy as the telephone on your desk. In a matter of minutes you can have assistance in more than a score of them—technical, safety, and marketing.

Are *you* taking full advantage of this fact?

If not, the chances are that you can save your company, and yourself, considerable time, effort and money, by supplementing your own operations with these many, varied, and helpful aids.

Check over the list on the opposite page. See if there isn't some way we can help you out—right now. Then just pick up your phone (or write) and tell us your wishes.

E. I. DU PONT DE NEMOURS & CO. (INC.) Petroleum Chemicals Division

WORLD PETROLEUM for July 15, 1955. Vol. 26, No. 8, July 15, 1955. WORLD PETROLEUM is published monthly by Mona Palmer, Trustee under the will of Russell Palmer, 604 Fifth Ave., New York 20, N. Y. Acceptance under Section 34.64 P.L.&R. pending at Bristol, Conn. Subscription rate: $5.00 per year, single copies $1.00. Copyright 1955, by Mona Palmer, Trustee.

How much time can *you* save by letting us do these things for you?

Technical

1. Regional laboratory services for work on problems involving the use of additives.
2. Blending plant design and construction engineering services. These include complete plans and special consultation.
3. On-the-road performance testing of your products by Du Pont Fuel Test Cars.
4. Fleet customer service by engineers ready to help you solve a fuel performance problem for a big customer.
5. Research is one of our long suits at Du Pont. If a particular problem is bothering you, perhaps our work can supplement yours for a quicker solution. Ask us about it.
6. Our specialized knowledge of chemical additives is always at your service. Whenever unusual problems arise, our chemists or engineers will be glad to lend you a hand in helping find the solution.
7. Technical literature covering many facets of additives use and research are available from Du Pont.
8. Improved tetraethyl lead handling equipment, such as the Metal-Flex unloading hose and the TEL Siphon Starter, has been designed and made available to the industry by Du Pont.

Safety

9. The Lead Hazard Clinic, covering all phases of safe TEL handling, makes an ideal supplement to your own training courses.
10. Easy-to-understand visual aids, such as our "Tank Talk" cartoon booklet, are excellent safety reminders for your personnel.
11. Stand-by service at tank entries, is quickly obtainable from Du Pont by telephone or telegraph.
12. "Maintaining Hygiene in Tetraethyl Lead Operations," written by 3 Du Pont doctors, is an authoritative book for your medical staff.
13. Speakers service—our medical personnel will be glad to address your employee safety meetings on the safe handling of TEL.
14. Movies on safety and other subjects can be readily obtained from Du Pont.

Marketing

15. Our new nationwide survey—"The Service Station Operator" gives dealer attitudes on such subjects as customer credit, dealer meetings, price wars and many other important aspects of service station operation. The first of five reports is now available.
16. Service station customer buying habits have been thoroughly studied in our documented survey, "The Service Station and the Motorist." It probably contains many of the answers you are looking for.
17. Visual aid presentations prepared by Du Pont, make ideal material for use in your dealer meeting programs.
18. Customer complaints about gasoline quality can be handled in a salesmanlike way by your dealers. We have a new movie, "When the Customer Says 'KNOCK,'" and a series of folders showing that "knock" is seldom the fault of the gasoline.
19. Advertising and sales promotion kits, prepared by Du Pont, can help you capitalize the advantages of additives in your fuels and lubricants.
20. The Du Pont quarterly survey of gasoline quality keeps you up to date on competitive octane standings and TEL content.
21. Our cartoon movie, "What Makes A Gasoline Good," can be used to show dealers and customers how quality is built into gasoline.
22. To help keep your dealers informed on the latest technical advances, members of our technical staff are available to address your meetings on a variety of subjects.
23. For your industry public relations, Du Pont contributes such programs as the "Magic Barrel Show."

Petroleum Chemicals

Regional Offices:
NEW YORK, N. Y.: 1270 Ave. of the Americas . . Phone COlumbus 5-2342
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TULSA, OKLA.: P. O. Box 730 . . . . . Phone Tulsa 5-5578
HOUSTON, TEXAS: 705 Bank of Commerce Bldg. . . Phone BLackstone 1151
LOS ANGELES, CALIF.: 612 So. Flower St. . . . . Phone MAdison 5-1691

IN CANADA:
Du Pont Company of Canada Limited
Petroleum Chemicals Division
80 Richmond Street, West
Toronto 1, Ontario

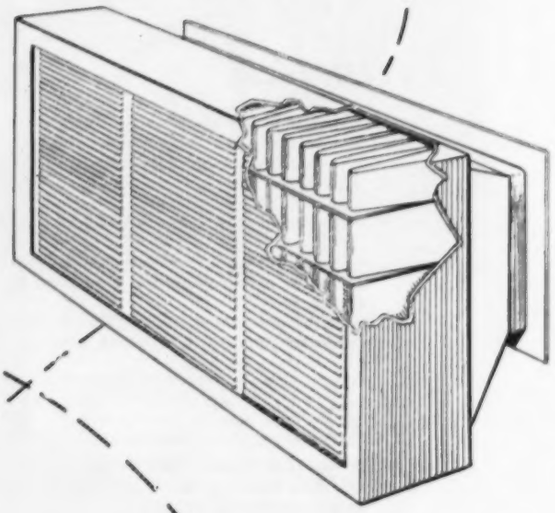
OTHER COUNTRIES: Petroleum Chemicals Export—Nemours Bldg., 6529—Wilmington 98, Del.

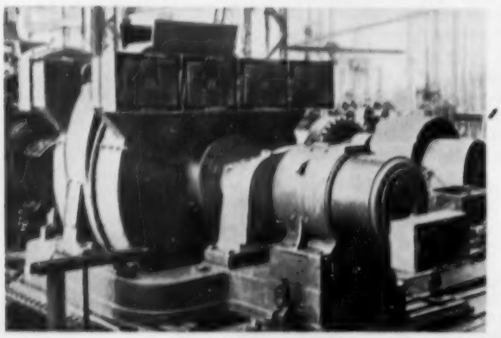
Wilmington 98, Delaware

VOKES FILTERS

play a vital part in keeping the oil flowing...

In the blinding desert dust storms which sweep the area of the Iraq pipelines, VOKES filters have twice been chosen for the important task of protecting pumping stations and ancillary equipment . . . proof indeed of the important part which VOKES filtration is playing throughout the world in safeguarding plant and machinery from wear, breakdown and unnecessary depreciation. Below are shown three typical aspects of VOKES protection . . . protection which cannot be jeopardized by the non-availability of element replacements because VOKES FILTERS ARE CLEANABLE.





MICRO-VEE PANEL FILTERS FOR ELECTRIC MOTORS

Electric motors breathe too! . . . and these VOKES filters have prove conspicuously successful in preventing the grave damage hitherto sustained during operations in impure air conditions.

VOKES FILTERS FOR ANCILLARY EQUIPMENT

Compressors . . . portable generators . . . welding sets . . . power packs . . . all need protection against the ingress of abrasive dust, whether by air-intake, lubricating oil or fuel.

VOKES FILTERS FOR STATIONARY DIESEL ENGINE

Under abnormal conditions like these, engines have to be doubly protected and these large diesel engines are therefore fitted with Microvee dry fabric filters for cleaning the intake air. Vokes Filters are also specified for atmospheric air filtration in the ventilating systems of many of the desert buildings.

VOKES LIMITED

VOKES LIMITED. *Head Office:* **GUILDFORD, SURREY, ENGLAND**

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V116A

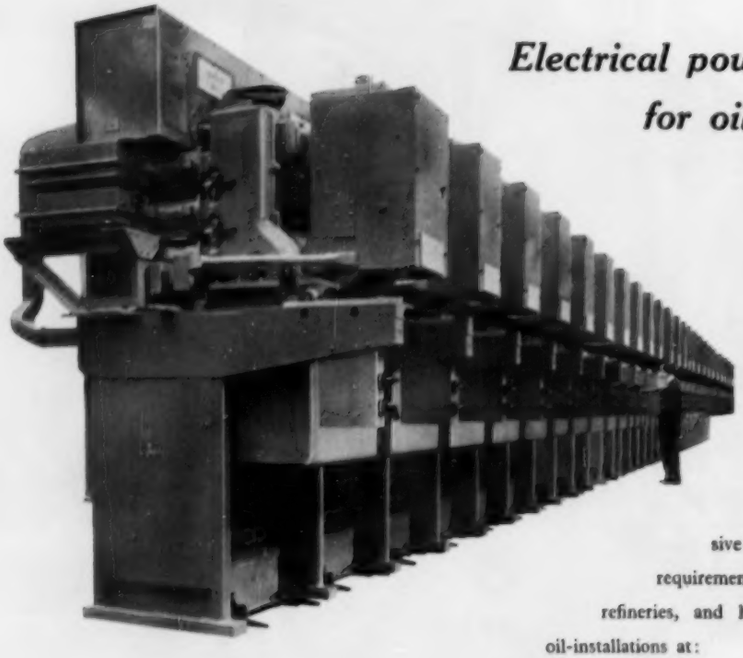
Round the World with BADGER....

In all four corners of the world Badger-built plants are turning out quality products for the Petroleum, Chemical, and Petro-chemical industries. Badger, with its completely integrated specialist organization, offers a step by step service from the basic design to the finished plant based on a sure foundation of knowledge and experience.

E. B. BADGER & SONS LIMITED

99 ALDWYCH, LONDON, W.C.2

Affiliated with STONE & WEBSTER ENGINEERING CORPORATION, Badger Process Divn., U.S.A.
Process Engineers and Constructors for the Petroleum, Chemical and Petro-Chemical Industries



Electrical power-control for oil-refineries

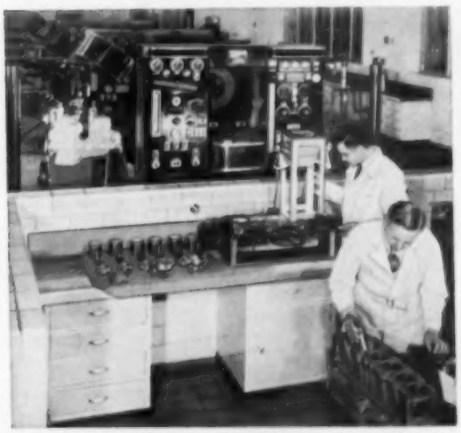
Reyrolle switchgear with its comprehensive range covers all requirements for modern oil-refineries, and has been supplied to oil-installations at:

CORYTON, GRANGEMOUTH, ISLE OF GRAIN, LLANDARCY, NORTHWICH, SHELLHAVEN, STANLOW, GEELONG, KWINANA, SARNIA, FRONTIGNAN, L'AVERA, SERIA, BOMBAY, VENICE, CARDON, MARACAIBO, HAMBURG, PERNIS, HAIFA, ABADAN, ADEN, IRAQ, and KUWAIT.

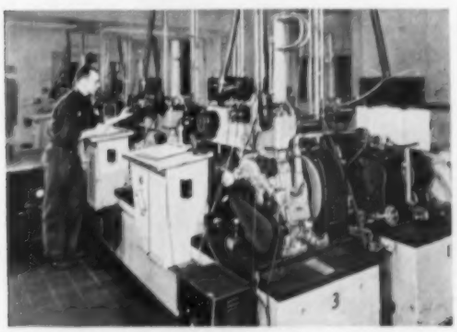
Reyrolle

A. REYROLLE & COMPANY LIMITED • HEBBURN · COUNTY DURHAM · ENGLAND

80 million miles of road testing in trucks and passenger cars is the background for Ethyl's development of new "Motor Plus." Road tests of the new compound, totaling 4,000,000 miles, confirmed its effectiveness.



500,000 total hours of testing antiknock fluids on multicylinder engines preceded the development of Ethyl's new "Motor Plus."



350,000 hours of single-cylinder testing gave our people the necessary background to develop Ethyl's new antiknock formula. Several thousand hours were devoted to the proving of "Motor Plus" alone.

New antiknock formula test-proved by Ethyl Research

Ethyl's new MOTOR PLUS the result of many years of work in developing improved antiknock compounds

Since "Ethyl" fluid was first sold, Ethyl research has made seven major improvements in fluid formulation to meet changing requirements in fuels and engines. New "Motor Plus" is the eighth.

Advantages to refiners

Our road and laboratory tests show that new "Motor Plus" does far more than just control knock.

For example, engine deposits are reduced—up to 12% (by weight).

The effects of deposits are reduced—
Knock reduced—up to 18%
Surface ignition—up to 25%
Exhaust-valve life is increased 35%.

Extensive test background

Using engines of representative types, we tested the new "Ethyl" compound for 2,500,000 truck miles and more than 1,250,000 passenger miles. In addition, we tested it in the laboratory for more than 10,000 engine hours. All tests confirmed the value of this formula in engines on the road today.

Research on antiknock compounds

Good as this new "Ethyl" formula is, our extensive research continues—working to find antiknock compounds best suited to the engine-fuel-lubricant environment of the future.

For more information about Ethyl's new antiknock compound, see your Ethyl representative. He will be glad to provide the details.

ETHYL CORPORATION
Research Laboratories

1600 West Eight Mile Road, Ferndale 20, Michigan
2600 Cajon Road, San Bernardino, California

CRANE PRODUCTS

for the Petroleum Industry

These are products which have been designed and manufactured to meet the various special requirements of the petroleum and allied industries.

TYPE 109 MECHANICAL SEAL This mechanical seal is designed to seal against corrosive and highly penetrating liquids associated with petroleum refining operations. Corrosion-resistant metals are used for the various components employed in the construction of the seal and a PTFE wedge ring is used to seal against leakage of the liquid along the surface of the shaft, and to impart to the seal the required degree of axial flexibility.

CRANPAC STYLE 100 AL A metallic gland packing, constructed with aluminium foil. This packing is designed for use in centrifugal and reciprocating pumps handling petroleum distillates at temperatures up to 1000°F. It is especially suitable for services associated with hot oil cracking and other refining processes.

CRANPAC STYLE 110 MP A resilient metallic packing constructed with soft frictionless foil which is machine-wrapped and crimped around a suitable core. This is a gland packing which is used extensively on all types of rotary and reciprocating pumps handling air, water, oil, hydrocarbon distillates and ammonia at temperatures up to 450°F.

CRANPAC STYLE 810 SP A packing constructed by braiding white asbestos yarn. This particular packing is impregnated with a special petroleum solvent-resistant lubricant.

SUPERSEAL STYLES SS2, SS3, SS5 AND SS6 Superseal gland packings approach, as near as is practicable, at present, to the ideal form of a gland packing—i.e. a fluid plastic. Superseal packings consist of a bonded but very pliable plastic substance. These Superseal packings, between them, are used in centrifugal and reciprocating pumps for services ranging from hot and cold water to oils at temperatures up to, and sometimes exceeding 850°F., and for services where acids, acid salts, caustic alkalis, and various chemicals are being handled.

THRED-GARD A heat-resistant compound which, when painted on the surface of threaded studs, bolts, and plugs etc., will protect the threads against the welding action resulting from prolonged exposure to extreme heat. Seizing and galling are prevented at operating temperatures up to 1200°F.

CRANE PLASTIC LEAD SEAL Used for pipe joints on services when oil, petroleum distillates and derivatives, gas, air, water, etc. are being handled.

There is illustrated literature for all the Company's products, and we would especially mention our Publications "GLAND PACKINGS" and "MECHANICAL SEALS"; copies of these publications will be sent on request.

Crane Packing LTD OF SLOUGH ENGLAND
A COMPANY

Monuments

TO SUN SHIP'S ACHIEVEMENTS IN BUILDING PRESSURE VESSELS.

SHIPBUILDING & DRY DOCK COMPANY

SINCE 1916

ON THE DELAWARE • CHESTER, PA.

25 BROADWAY • NEW YORK CITY

200 ft. High!

Insulated from top to bottom with

ROCKSIL

Regd. Trade Mark

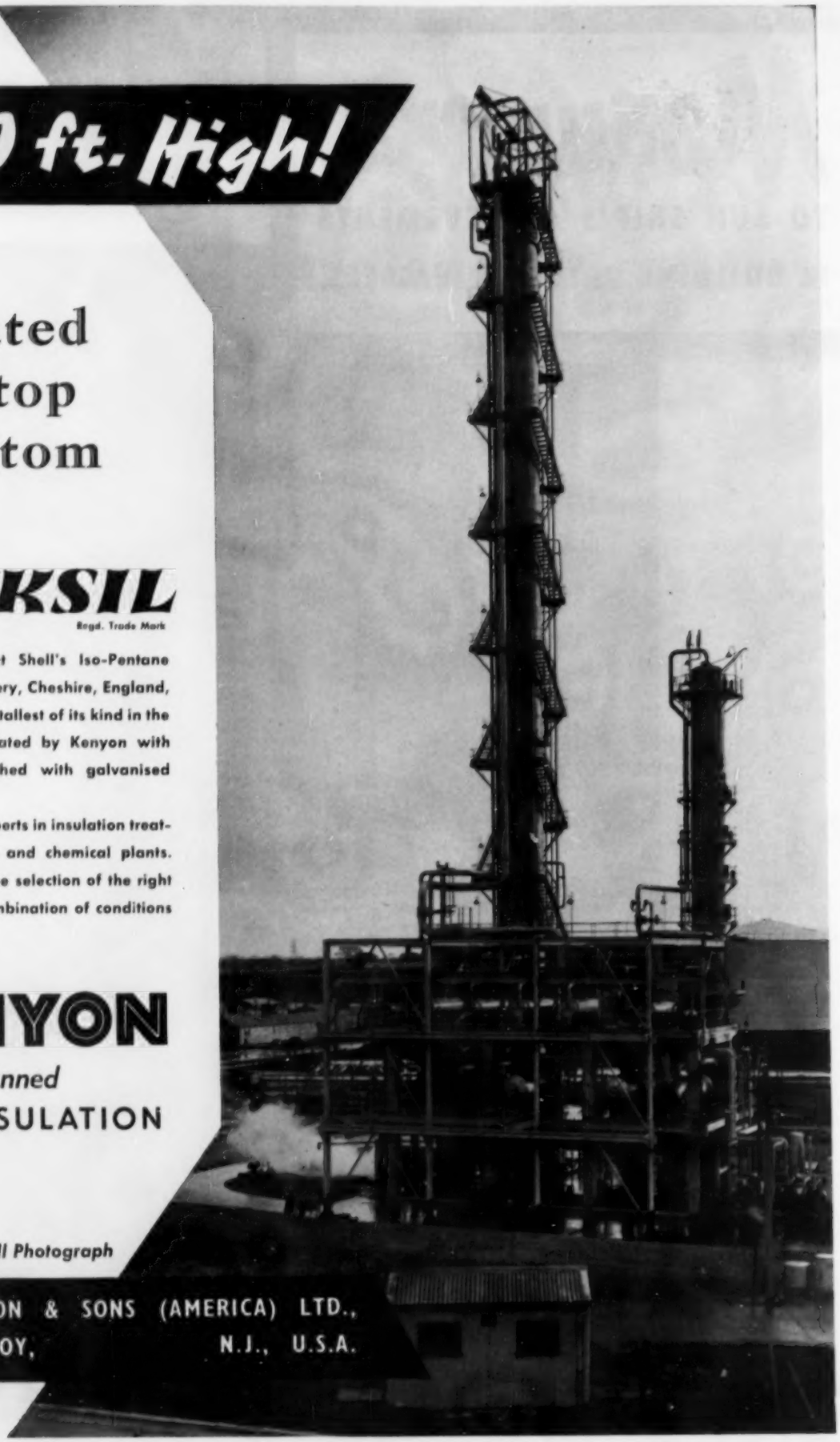
This column at Shell's Iso-Pentane plant, Stanlow Refinery, Cheshire, England, is believed to be the tallest of its kind in the world. It was insulated by Kenyon with "Rocksil" and finished with galvanised sheet.

Kenyon are experts in insulation treatment for petroleum and chemical plants. They specialise in the selection of the right material for any combination of conditions or circumstances.

KENYON

Planned

HEAT INSULATION



A Shell Photograph

WM. KENYON & SONS (AMERICA) LTD.,
PERTH AMBOY, N.J., U.S.A.

WILLIAM KENYON & SONS LTD., DUKINFIELD, CHESHIRE, ENGLAND

KM182

MATTHEW HALL & CO., LIMITED

CHAIRMAN'S SPEECH

The Twenty-Eighth Annual General Meeting of Matthew Hall and Co., Limited, was held on 25th May, 1955, at Matthew Hall House, Dorset Square, London.

Mr. Bertram Baden, M.C., S.B.St.J., M.I.H.V.E., the Chairman, presided.

The following is his statement which was circulated with the report and accounts:

I am happy to report another successful year.

The Group Profit on Trading for 1954 was £360,774 (1953 £208,764) and after deducting Directors' Remuneration, Depreciation and Provision for Deferred Repairs, there remains a Net Profit before taxation of £286,034 (1953 £133,662).

Partly because your Board is considering the inauguration of a superannuation scheme for established staff they have, on this occasion, placed £41,000 to General Reserve (1953 £20,000). It is recommended that a dividend of 30% (1953 22½%) be paid, leaving £225,279 (1953 £122,868) to be carried forward in the Group's Accounts.

The Directors also recommend that £60,000 of the Company's reserves be capitalised and applied in paying up in full 240,000 new Ordinary Shares of 5/- each to be issued to members in the proportion of one new share for every two shares already held.

Self-financing Contracts have again been generally predominant both here and abroad, resulting in a further increase of our liquid resources.

The Company continues to play an important part in the fields of air-conditioning, heating, electrical and sanitation and undertakes contracts combining all of these services. An increasing number of clients make use of the facility of placing all mechanical services with one contractor, which they find makes for economy, speed and convenience.

Our chemical, oil refinery and industrial engineering projects, which include design, procurement and erection, have increased.

AIR-CONDITIONING DIVISION.—Among air-conditioning contracts secured during the year were the American owned Westbury Hotel in New Bond Street, a large office block at Holborn Viaduct, laboratories and air conditioning for various industrial processes.

Contracts overseas include fully air-conditioned hospitals in Aden and Qatar and a film centre in Ceylon.

ELECTRICAL.—Industrial work included instrumentation and lighting and power for chemical and oil refinery plants.

During the year we completed services to two thousand Reema houses.

Installations overseas included generating plants and ancillaries for power stations, and offices and workshops in West Africa and Iraq.

CHEMICAL, OIL REFINERY AND INDUSTRIAL ENGINEERING DIVISION.—We have been increasingly engaged on the design, procurement, construction and commissioning of process plants including de-gassing columns, a batch distillation unit employing induction heating, double effect evaporators and sulphur melting plant.

Other work included erection of sulphuric acid, catalyst production, and benzole distillation plants, also rotary kilns each 284 feet long. In our factories, we manufactured skid mounted gas separating stations for Venezuela.

Our drawing offices are among the largest and best equipped in the country.

ATOMIC WORK.—This country has taken a lead in the development of atomic energy for industrial purposes and we are proud that we have been engaged on engineering work on all the major atomic research establishments in the country, including Britain's first atomic electricity generating station.

PLUMBING AND GARCHEY.—Among our plumbing contracts in London is the Bank of England's premises at St. Paul's Precincts. During the year, we completed plumbing services to some thousands of houses.

The Garchey system of refuse disposal was completed on a large block of flats in Newcastle, also one at Birmingham where a further installation is in hand.

MATTHEW HALL (PTY.) LTD., SOUTH AFRICA.—During the year, this Company doubled its turnover despite keener competition.

For the mines and the uranium industry, we have manufactured and installed miles of piping, up to 30 ins. in diameter—the Free State mines alone used over 40 miles.

The Chemical Division has carried out chemical leadwork for sulphuric acid plants, leadlining of absorption towers for an auto-oxidisation plant and lead acid transfer piping for a pyrites recovery plant.

Other contracts included work on uranium oxide extraction and concentrate plants, fume removal, scrubbers and building pressurisation for a tungstic acid plant.

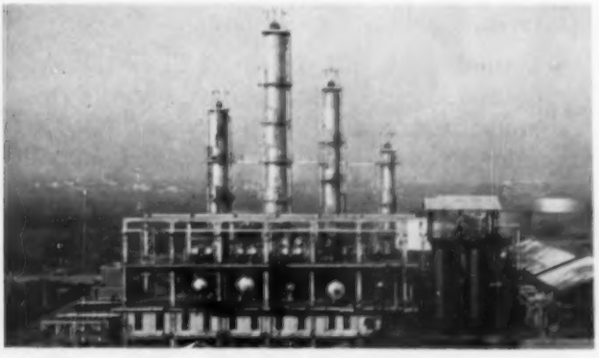
The Automatic Sprinkler Division carried out installations in all four Provinces of the Union in departmental stores, offices, factories and warehouses.

FEDERATION OF CENTRAL AFRICA.—Our Rhodesian Branches have extended their activities, and orders cover air conditioning, sanitation and automatic sprinklers to hotels, flats, offices, factories, schools, hospitals and a research station.

The leadburning contracts at the copper mines continue.

This review would not be complete without reference to the capable and enthusiastic way in which our large staff and other employees at home and overseas have fulfilled their duties, and it gives me pleasure to express to them the most sincere thanks of the Board.

The report and accounts were adopted.



Plant Erection

A section of one of our drawing offices.

Scammell

FOUR AND SIX WHEEL DRIVE TRUCKS

Illustration above shows one of the many 6 x 6 Scammell "Constructor" Oilfields Bed Tractors operating in Kuwait and other major oilfields of the world.

Built to 'take it' *on or off the highway*

Scammell 4 x 4 "Mountaineer" Oilfield Tractor.

Scammell four and six wheel drive trucks have been specially designed for operation under the most gruelling conditions. In tropical heat, in the Arctic snowy wastes, in soft, sandy or mountainous terrain—in fact wherever the going is rough and tough Scammell trucks provide the complete, economical and reliable answer for every type of oilfield transportation.

Scammell four and six wheel drive oilfield type trucks and tractors have chassis designed for mounting Well-servicing Hoists, Cranes, Excavators, Drill Rigs, Cement Transit Mixers, etc., etc.

Further details gladly sent on request.

SCAMMELL LORRIES LTD., WATFORD, HERTS., ENGLAND *Telephone: Watford 5231; Telegrams: Twelfton, Watford*

BOTH EYES OPEN

There are darn few supply stores in the jungles of Brazil or the rugged hills of Portugal. And that's one of the reasons why plant executives with an eye on foreign operations choose BORN "UPFLO" HEATERS. Repairs, maintenance, or shut-downs in these remote areas are costly, so a heater which can deliver year after year of trouble-free operation will result in tremendous savings.

But there's *another* side to the story of Born's popularity, too. In North America, Born heaters are saving millions of dollars every year, even though they may be right next door to a supply house! That's because BORN "UPFLO" HEATERS are *more efficient;* save on fuel costs every day they're in operation.

At this moment, BORN "UPFLO" HEATERS have been furnished for service in India, the Philippines, Formosa, Brazil, Venezuela, Colombia, Italy, Japan, and Portugal — in addition to the hundreds of Born heaters all over the United States and Canada. Over 1,000,000 barrels of Petroleum Oils and Distillates *per day* are being economically processed by these efficient, rugged units.

Just where the next "UPFLO" heater will crop up, nobody knows. But you can bet your best "Stetson", it will be ordered by an executive who does his buying with *both eyes open!*

BORN *Engineering Company*

ENGINEERS and CONTRACTORS

TULSA, OKLAHOMA

BRANCH OFFICES:
Denver, Colo.; Houston, Tex.; Los Angeles, Calif.; New York, N. Y.; Shreveport, La.

FOREIGN OFFICES:
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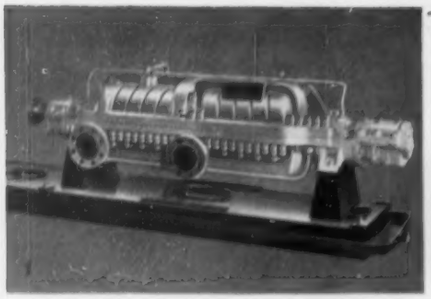
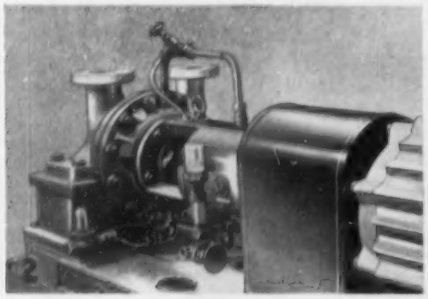
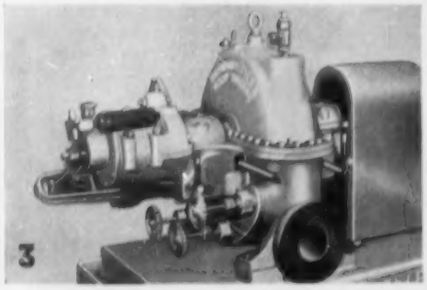
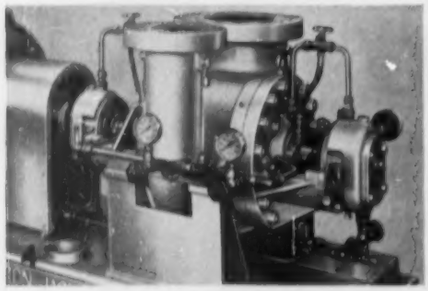
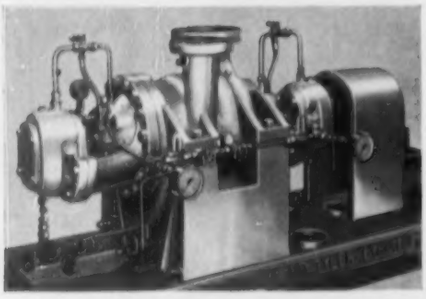
Brander & Cia. S. A.
Tacuari 310
Buenos Aires, Argentina
Prematrance
36 Boulevard Gouvion St. Cyr
Paris 17, France

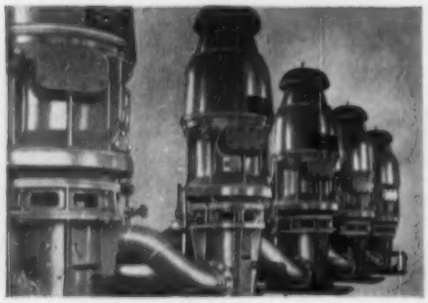












In engineering as in music

some achieve excellence

and every one of the products illustrated here is a first-class example of its kind.

1. Hayward Tyler—Byron Jackson DVMX Pump for high pressure pipeline service. For heads up to 4,000 feet.
2. Hayward Tyler—Byron Jackson SM (Saddle Mounted) Process Pump for Temperatures up to 800°F., with provision for cooling stuffing box and bearings and with choice of gland packing or mechanical seal.
3. Hayward Tyler—Terry steam turbine especially suitable for driving pumps handling explosive liquids. Will operate as a pressure reducing valve where a boiler installation exists for heat or process work.
4. Hayward Tyler—Byron Jackson DSHO (Double Suction Hot Oil) Pump for handling high temperature liquids on continuous operation with maximum freedom from cavitation.
5. Hayward Tyler—Byron Jackson VC (Vertical Cut) two-stage Pump for temperatures up to 900°F. and capacities up to 5,000 Imperial gallons per minute.
6. Hayward Tyler—Byron Jackson VMT and VHT Pumps for handling hot or cold, corrosive or non-corrosive liquids wherever the nett positive suction head is limited. Eliminates underground pumping stations.

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& CO., LTD.
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TELEPHONE: LUTON 6820-9

TELEGRAMS: TYLEROX TELEX LUTON

LONDON OFFICE: SALISBURY HOUSE, FINSBURY CIRCUS, E.C.2

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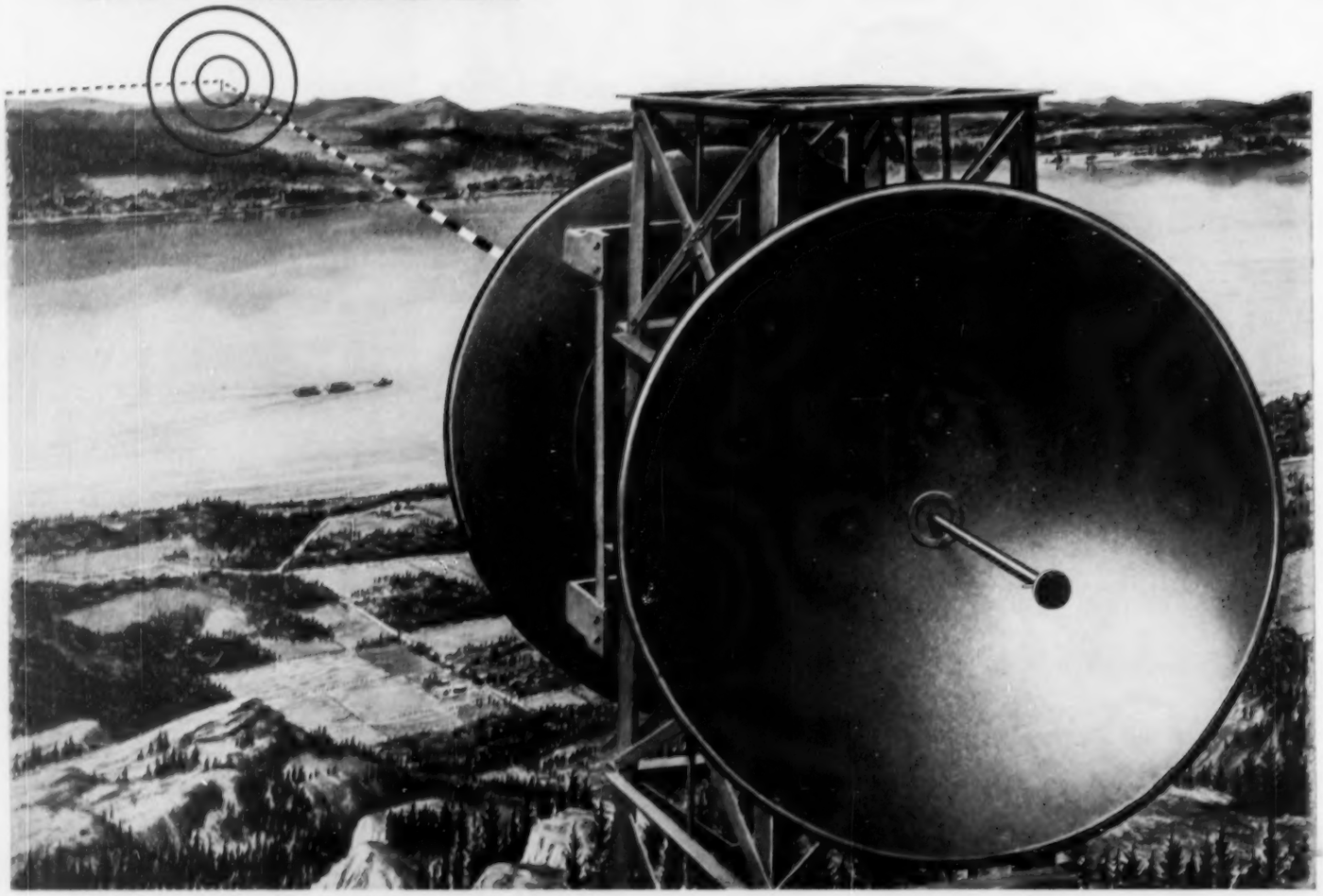
The giant "cat" crackers at the four Cities Service refineries are put through their paces twenty-four hours a day. They are so well trained they refined 83,940,000 barrels of crude oil for Cities Service in 1954, and turned out more 5-D Premium Gasolene than ever to meet growing customer requirements, which have gone up at double the rate for the industry as a whole.

CITIES SERVICE

A Growth Company

Number 9 of a series

"ON TARGET"



. . . FOR ALL-INCLUSIVE, ALL-WEATHER COMMUNICATIONS THROUGH MICROWAVE

Microwave goes straight to the core of communications problems—with a simple solution! No costly wireline construction or maintenance . . . dish-like antennas beam the microwave signal between line-of-sight points separated by waterways, jungles, forests, or mountainous areas. Transmission is completely reliable, for it is *unaffected by weather*. Simultaneous, multi-channel operation easily accommodates the volume and variety of communications so vital to modern business. For example, as many as 19 telegraph circuits can be carried by any *one* of the many telephone channels provided by the ISE system.

Microwave was successfully demonstrated for the first time in 1931 by International Telephone and Telegraph Corporation. Today this system, developed and improved through the years, is made available outside the United States through ISE, associate of IT&T. Would you like the facts on what microwave can mean to *your* communications? ISE engineers will be happy to consult with you.

International Standard Electric Corporation

ISE — an IT&T associate

Export Department, 50 Church St., New York 7, N. Y., U. S. A.

Central telephone exchange equipment for installations of any size, automatic or manual.

Cables, wires, conduits, structures—equipment and supplies for every communication and power need.

Radio aids to air navigation . . . complete airport communications and lighting systems.

Teleprinters for automatic transmission and reception of written messages.

All equipment for television and radio broadcasting and receiving . . . point-to-point communication.

MANNESMANN

LARGE-SIZE TANKS

For over 50 years,

the Mannesmann seamless tube has occupied a very definite position as one of the most important structural members in the petroleum industry. Mannesmann Drill Pipe and Casing for the production of petroleum are giving unfailing service in all parts of the world. Mannesmann Pipe Lines are used extensively for the transmission of oil over long distances, and Mannesmann Oil Tubing for refinery service. We are also world-wide suppliers of Large-Size and Storage Tanks made of Mannesmann steel plates. We are specially equipped for the fabrication of steel plate tanks of welded or riveted construction for the storage of all kinds of liquids, and for the manufacture of welded or riveted transport and storage containers for all uses. The use of selected steel grades and the adoption of the latest welding processes assure a high resistance capacity and maximum safety in operation of all tank installations supplied by us.

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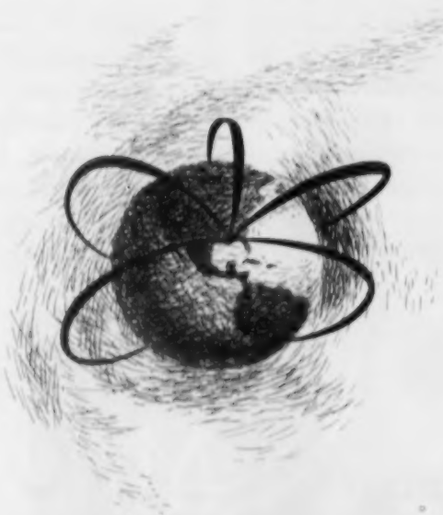
WORLD-WIDE SYSTEM OF REPRESENTATIVES

Offshore drilling platform built by Avondale for the CATC group (Continental Oil Company, Atlantic Refining Co., Tide Water Associated Oil Co., and Cities Service Oil Company).

from the heart of the South . . . serving the Nation and the World

Avondale



. . . 4 divisions to serve Industry: the Main Plant at Avondale; shipbuilding, ship repair, steel fabrication—the "Quick Repair" Plant on the Harvey Canal; drydocking and propeller service—the Service Foundry Division; iron, steel and non-ferrous castings, gear cutting and machine work—and the new Avoncraft Division; manufacturing porcelain enamel and collateral architectural products. All these are Avondale, serving Industry from the heart of the new South . . .

AVONDALE MARINE WAYS, INC. NEW ORLEANS

International Paints

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The associated "International" factories in New Jersey and California are manufacturing paints for a variety of purposes. They have on-the-spot experience of paints for the American market plus the wealth of information accumulated by the "International" world-wide organisation. "International" have associated companies in 16 countries and all combine in contributing information about paints and techniques so that it is possible for all factories to supply the best paint for anything, anywhere. "International" products for the oil industry include METAL PRIMERS and ALUMINUM PAINT for storage tanks; DRUM PAINTS, and ENAMELS for general purposes. Why not call in "International" next time you need paint?

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THE STEEL TUBE AGE

S & L steel casing,

9⅝-inch outside diameter,

being prepared for stringing at a location

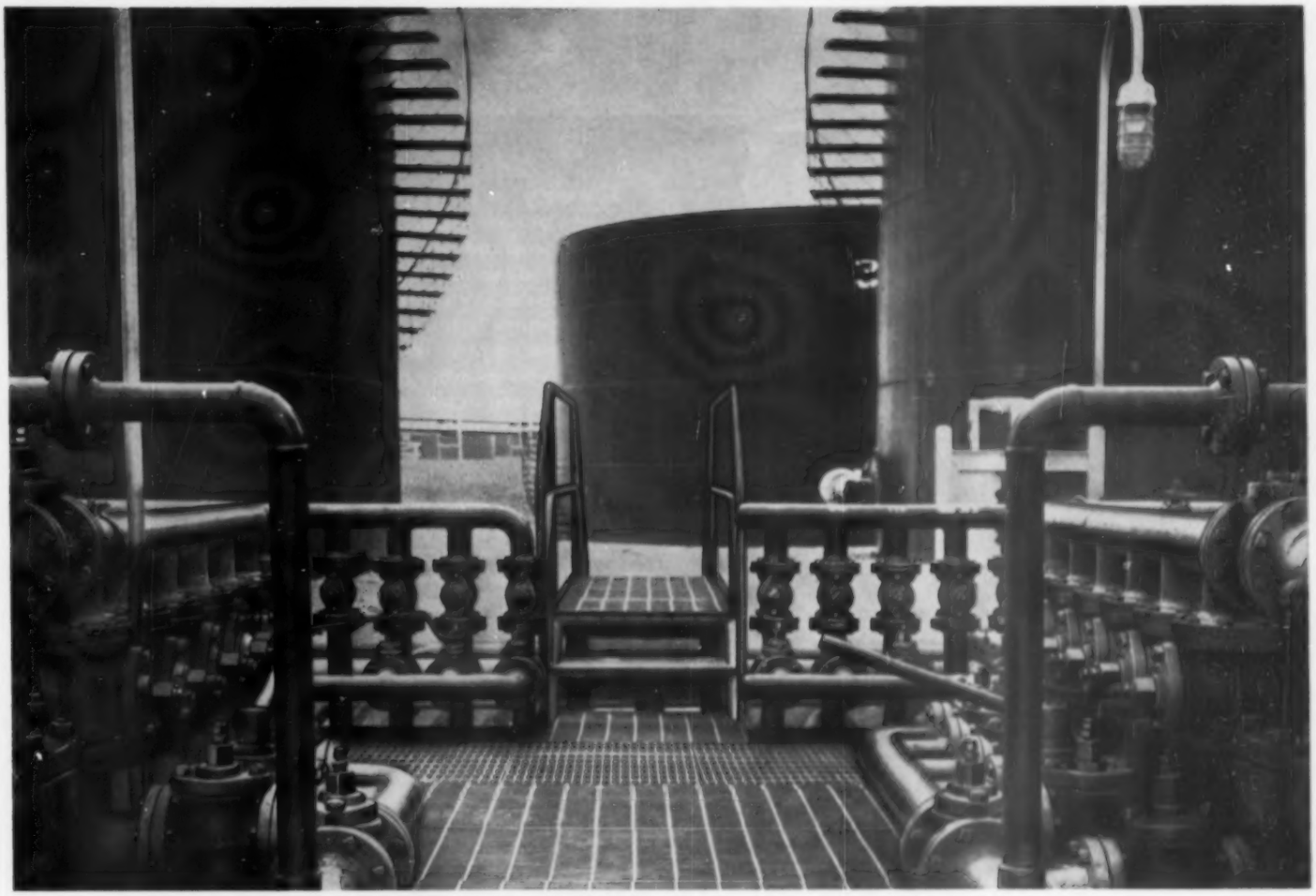
of Imperial Oilfields Ltd., Alberta, Canada

STEWARTS AND LLOYDS LIMITED

GLASGOW · BIRMINGHAM · LONDON

The largest manufacturers of steel tubes in Europe

S&L

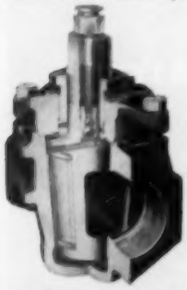


Costs Down . . . Production UP

because **Audco**-Nordstrom **Valves** perform better, longer, for less money!

In key spots, where dependability is vital, you *expect* to see Audco-Nordstrom valves. They were created forty years ago for the tough jobs ordinary valves couldn't handle.

But now you also see them—by the hundreds *and thousands*—in "routine" services like the tank manifold shown above, and for the same basic reasons:



—they're ruggedly dependable, yet cost no more than ordinary valves.

—they're pressure-lubricated, to provide a truly tight, dependable seal . . .

—the lubricant film prevents grinding metal-to-metal wear, means longer life, less down time, lower maintenance cost . . .

—quarter-turn, and the hydraulic-jack action of the lubricant, make them quick and easy to operate, once a day or once a year . . .

Audco-Nordstrom is the *original* lubricated plug valve, and for 40 years has been the plug valve leader. That's why Audco-Nordstrom can give you the most complete range of sizes, pressure-temperature ratings, body designs, and metals.

Why not standardize on Audco-Nordstroms—and genuine Audco-Nordstrom lubricants—for your fuel, products, supply and transfer lines? You'll get better valve service than you've ever had before, and at lower cost per year. There's an Audco-Nordstrom representative near you; get in touch with him or contact the offices listed below.

AUDCO and Nordstrom

BRITISH
AUDLEY ENGINEERING COMPANY, LTD.
Newport, Shropshire
England

OVERSEAS AGENTS located in South Africa, Australia, India, Trinidad, British West Africa, Finland, Norway, Sweden, France, Belgium, Switzerland, Italy, Spain and Portugal

AMERICAN
ROCKWELL MANUFACTURING COMPANY
400 N. Lexington Ave.
Pittsburgh 8, Pa.

EXPORT: International Department
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HARSHAW produces carloads of catalysts *every week*

HARSHAW

Write for our free booklet, "Harshaw Catalysts"

HARSHAW CATALYSTS AVAILABLE IN 7 FORMS

- Tablets
- Powders
- Granules
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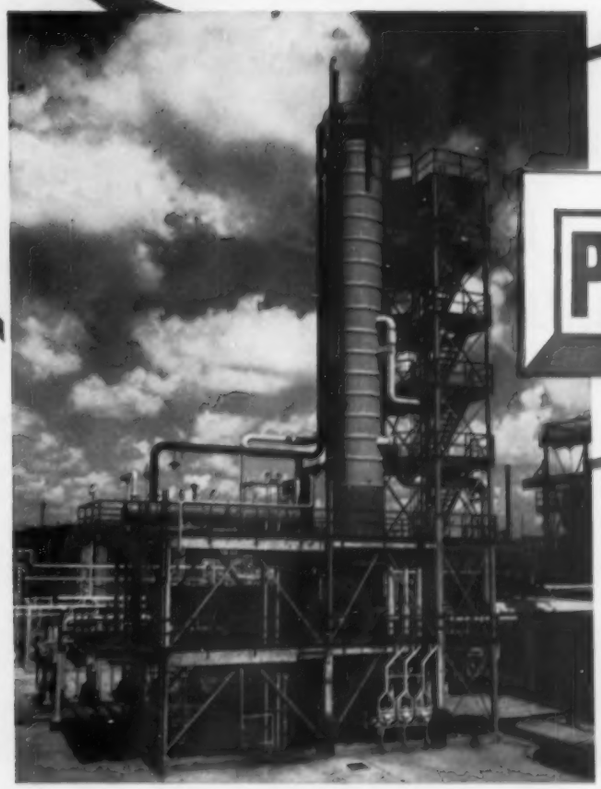
GETTING THE BEST OF OIL !



PARSONS

When Esso Standard Oil Company wanted a distillation unit for lubricants production they selected The Ralph M. Parsons Company from competitive bidders to do the job. This plant has been in operation at Baton Rouge, Louisiana, for nearly a year.

By having Parsons handle mechanical design, procurement and construction, Esso gained all the advantages of working with a single organization with a single responsibility.

THE RALPH M. PARSONS COMPANY

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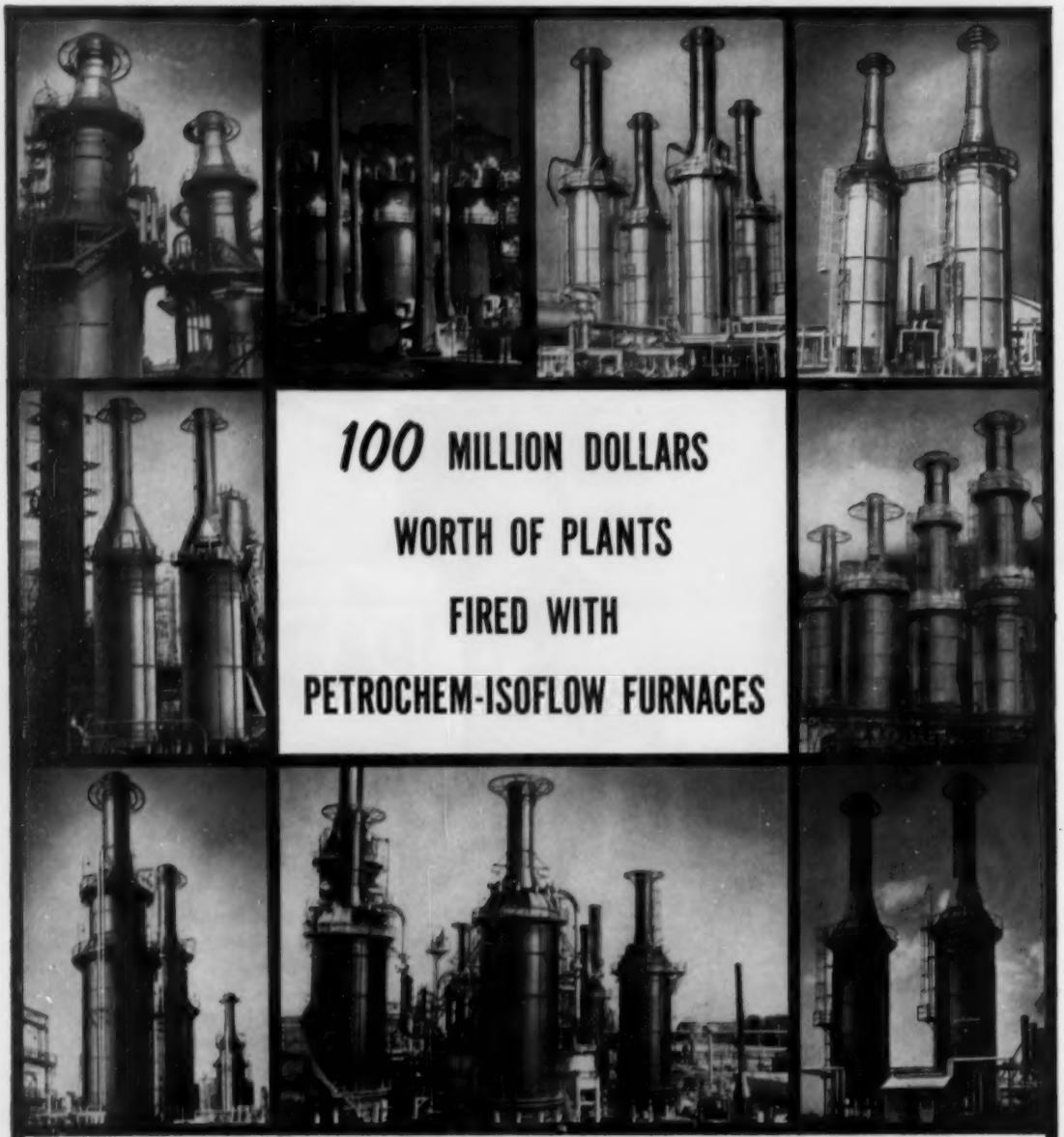

100 MILLION DOLLARS WORTH OF PLANTS FIRED WITH PETROCHEM-ISOFLOW FURNACES

More than 1250 Petrochem-Isoflow Furnaces are in operation throughout the world in the petroleum, chemical and allied industries . . . for all processes and for any duty, pressure, temperature and efficiency . . . and all Petrochem-Isoflow Furnaces are most efficient by any comparison.

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UNLIMITED IN SIZE ... CAPACITY ... DUTY

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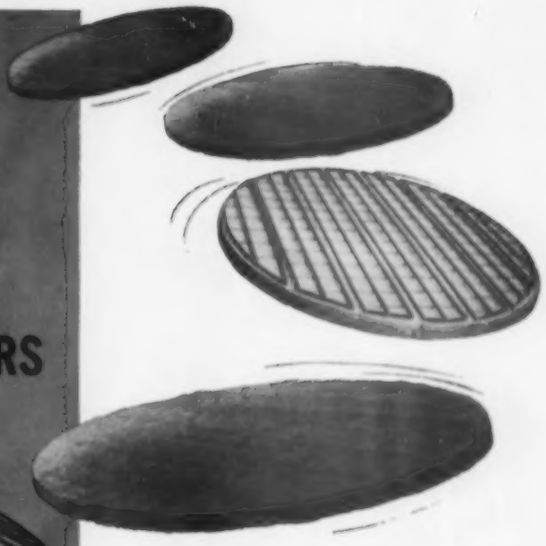
Get Improved Performance

In Process Equipment

by Clean Separation

between Vapors and Liquids

with YORKMESH DEMISTERS



Yorkmesh Demisters are answering Chemical Engineers demands the world over for a simple means of improving the performance and increasing the capacities of process equipment handling vapor and liquid materials.

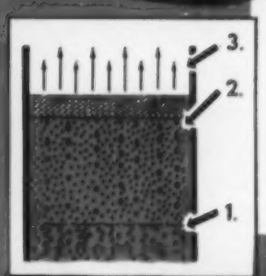
- *Higher vapor velocities can be used.*
- *Overhead product quality is improved.*
- *Entrainment losses are eliminated.*
- *Overall operating efficiency is improved.*
- *Easily installed in existing or new equipment.*

How YORKMESH Demisters work inside Vacuum Towers

Vapor disengaging from liquid creates fine liquid droplets which are carried as entrainment by the vapor stream.

The liquid droplets impinge on the fine wire surfaces of YORKMESH, and are coalesced into large drops which run down and fall off the YORKMESH.

The vapor is now dry. It has been entirely freed from entrained liquid. Thus a clean gas-oil goes to the catalytic cracker.



For use in:	Prompt shipment in:
Vacuum towers	Monel, Nickel
Distillation equipment	304-316-430
Absorbers	Stainless Steels
Scrubbers	Carbon Steel
Separators	Copper, Aluminum
Evaporators	Inconel and
Knock-out Drums, etc.	Other Alloys

Write for new Catalog 55 for complete information and engineering data on YORKMESH Demisters.

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IN THE APPLICATION OF RUBBER TO OIL PRODUCTION—

Part of the Shell refinery at Cardon in Venezuela. (*A Shell photograph*)

Service assures success—

Dunlop Oil Suction and Discharge Hose to British Standard Specification 1435 Type 3. This 8" bore hose is suitable for use at working pressures up to 200 lb./sq. in. Photograph shows the hose at one stage of the rigourous testing programme to which every length is subjected.

The Technical Advisory Service that Dunlop offers the oil industry plays a great part in *the consistent success* of Dunlop equipment in oil installations throughout the world. Experience of installations operating in every conceivable condition enables Dunlop experts to provide thoroughly practical, up-to-date guidance on new projects, extensions, replacements, repairs and development. In this way, the most efficient use is made of equipment designed for the job with characteristic Dunlop thoroughness.

The range of Dunlop products for the industry is indicated below. To take advantage of the Service offered, simply contact your nearest Dunlop distributor or representative — or write to the address below.

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A WORLD WIDE SERVICE TO THE OIL INDUSTRY

OIL SUCTION & DISCHARGE HOSE, SLUSH PUMP HOSE.
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DUNLOP RUBBER CO. LTD. (GENERAL RUBBER GOODS DIVISION), MANCHESTER, ENGLAND

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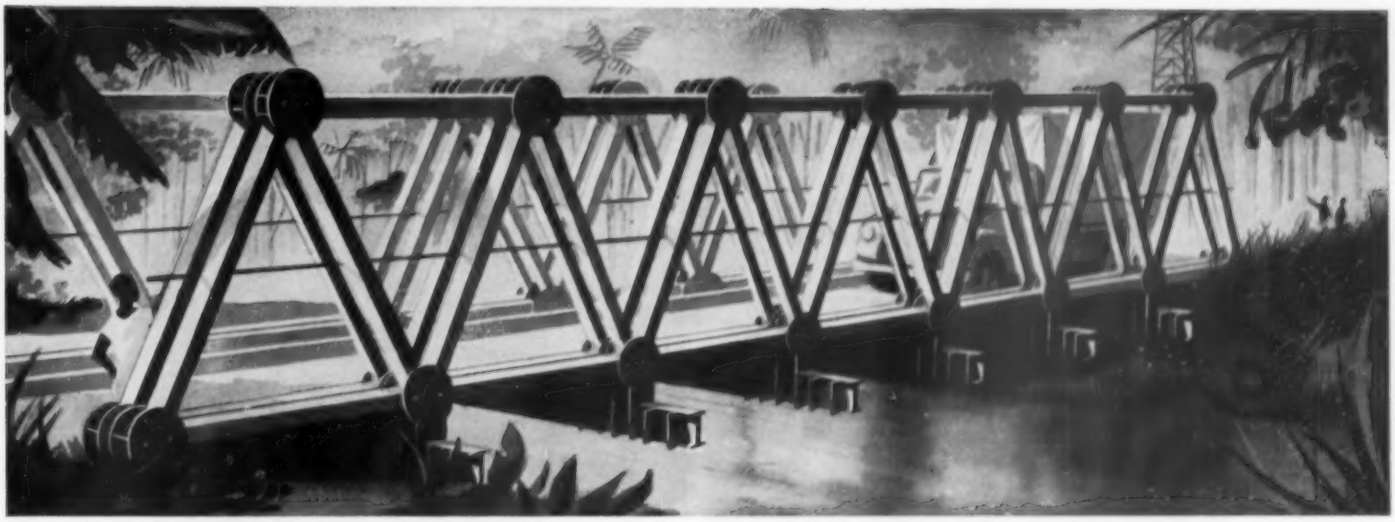
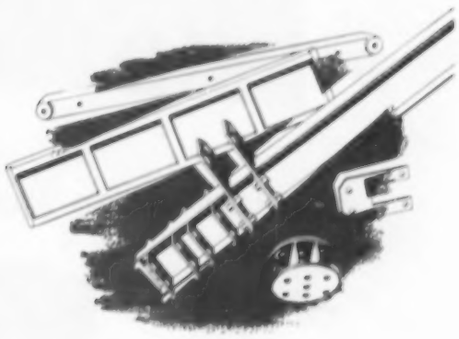
Easily transported to . . .

and quickly erected on . . .



remote up-country sites

Butterley Standard-Unit Bridges are in use all over the world where transport is difficult, skilled labour scarce or where site preparation has to be carried out under adverse conditions. From five standard units, all sizes of bridges can be built; the units can be sent by any form of transport; site erection is remarkably simple and swift with an absolute minimum of equipment.



THE BUTTERLEY STANDARD-UNIT BRIDGE

THE BUTTERLEY COMPANY LIMITED RIPLEY DERBY ENGLAND

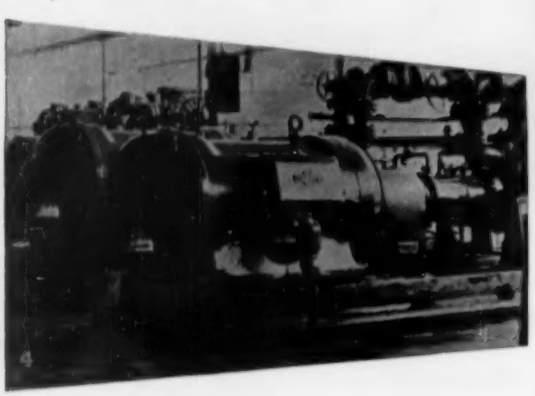
London Office: 9 UPPER BELGRAVE STREET S.W.1.

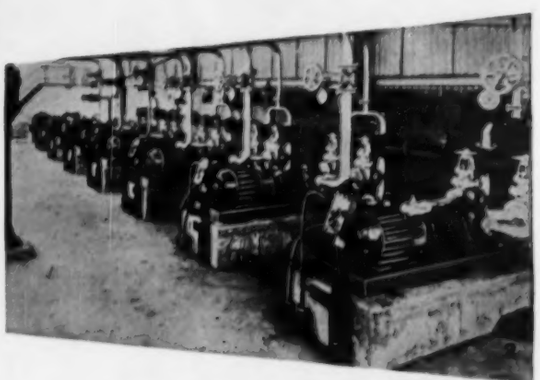
FLAMEPROOF MOTORS

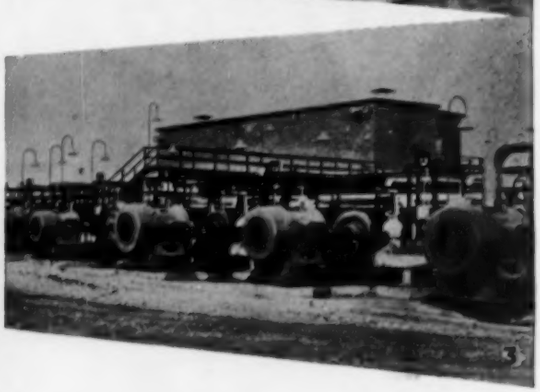
certified for group 2 and group 3 gases

A complete range of Metrovick Buxton-certified flameproof motors is available for refineries and petro-chemical works, for either indoor or outdoor use. Machines with either ball and roller bearings, or sleeve bearings, can be supplied, and all are suitable for hot product pumps.

A specialised range of splash-proof well-pump motors and industrial type machines for non-hazardous locations is also available.







1. A range of flameproof motors in one of the main pumping stations at Scottish Oils, Grangemouth Refinery. 2. Type KFB flameproof motors driving Sigmund pumps at Shell Stanlow Refinery. 3. 300-600 hp outdoor flameproof motors at the product loading station at Esso Refinery, Fawley. 4. 125 hp 3500 rpm T.E.F.C. motors driving oil pumps at Trinidad Leaseholds Pointe-a-Pierre Refinery, British West Indies.

METROPOLITAN-VICKERS

ELECTRICAL CO LTD · TRAFFORD PARK · MANCHESTER, 17

Member of the A.E.I. group of companies

J/M301

KNOWLEDGE
a power for good

The Standard-Vacuum organization is continually expanding its educational and training programs for its 40,000 employees in the various areas where it operates.

In Indonesia, for example, 71 formal training courses as well as on-the-job instruction are giving several thousand men new skills . . . teaching them to work as a team and to produce more . . . improving their ability to shoulder responsibility . . . adding to their economic security as individuals and their economic strength as citizens.

Stanvac seeks to do its part in developing the capacities of its employees so that they become better qualified to carry on the company's operations and to participate in supervisory and administrative functions.

Greater knowledge is truly a power for good.

STANDARD-VACUUM OIL COMPANY

A name that stands for "Progress" in the East

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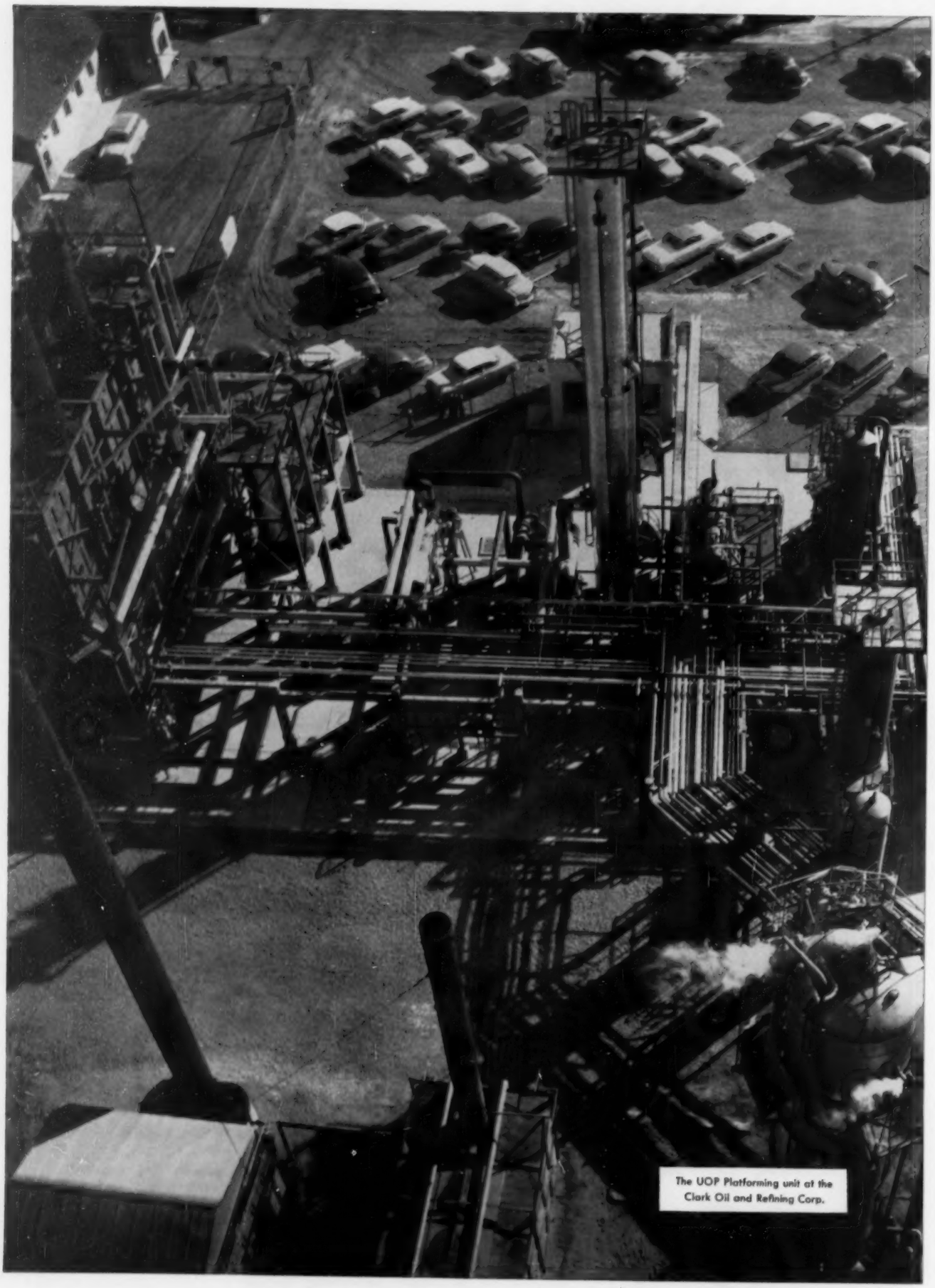

The UOP Platforming unit at the Clark Oil and Refining Corp.

Clark Oil and Refining Corporation Finds Platforming Valuable in Producing High Octanes

By John Stackner
General Manager
Clark Oil and Refining Corporation, Milwaukee, Wis.

THE UOP Platforming process, installed recently at our Blue Island, Ill., refinery, has made it possible for Clark Oil and Refining Corporation to assume a leading role in marketing high octane motor fuel in the Chicago area.

John Stackner

We are at present marketing a finished gasoline of 96 plus leaded octane, which is one of the top quality motor fuels being sold in the Chicago area. This is being sold as our new "Platinum Powered Clark Super 100 Gasoline," and it is produced in our Platformer. However, the unit will produce higher octane gasoline if needed. In fact, on test runs, the Platformer has produced 100 leaded octane motor fuel without temperatures being pushed to the design limit.

Aside from assuring us of sufficient octanes for some time to come, the Platforming process has permitted us to greatly expand our retail marketing program by making available an adequate supply of the best quality gasoline.

Closely tied in with the start up of the Platforming unit last November was the opening of 27 new, modernistic service stations in the Chicago area, marking the first time that Clark has invaded this particular gasoline marketing field. Almost simultaneously, more than 100 other retail outlets in several states, which had been flying the banner of other independent companies, were acquired by our company, and began to sell the new "Platinum Powered" gasoline for the first time in their areas. Clark now has more than 325 retail outlets in eight states—Illinois, Indiana, Michigan, Wisconsin, Minnesota, Iowa, Kansas and Missouri—an increase of approximately 100 per cent in little more than a year.

Can Produce Only Premium

The Platforming process has also given our Blue Island refinery the distinction of being one of the few in the Chicago area able to produce only premium motor fuel. We are in this enviable position because the Platformer can adequately handle the refinery's entire output of straight run gasoline without any of it being diverted to the production of less profitable materials. This of course reflects favorably on the increased profitability of the overall refinery operation.

The Platforming unit has a design capacity of 5,500 barrels per day, and it is currently operating at two-thirds of capacity in handling the crude unit's entire production of straight run gasoline. But a capacity operation can be assured by drawing upon additional supplies of straight run from the company's other refinery at Marrero, La., a suburb of New Orleans. However, an increase in the capacity of the Blue Island plant's crude topping unit from 16,000 B/SD to 20,000 B/SD will make it unnecessary to ship charge stock from Marrero for full capacity operation.

Another important advantage which has accrued to Clark through installation of the Platforming process has been the increase in the production of premium gasoline. Under our previous operation, the refinery's daily production of 93 leaded octane premium ranged from 50 to 55 per cent of the total gasoline made. With the Platformer, the production of premium has risen in excess of 90 per cent of the total gasoline output, and the octane has been increased to 96 plus.

Extensive Modernization Program

An extensive refinery modernization and expansion program was centered around installation of the Platformer, which was designed, engineered and licensed by Universal Oil Products Company. The unit was built by Procon Incorporated in about six months. We also are planning to convert one of two existing thermal reformers, which are now shut down, to a thermal cracking unit in order to supplement the yield of gasoline from a 7,500 B/SD catalytic cracking unit.

We regard Platforming as one of the greatest developments ever made in the refining field. The process has enabled Clark to become a leader in marketing top quality motor fuel in the highly competitive Chicago area. The public response to our new "Platinum Powered" Clark Super 100 gasoline has resulted in one of the biggest upswings in business in our 21-year history.

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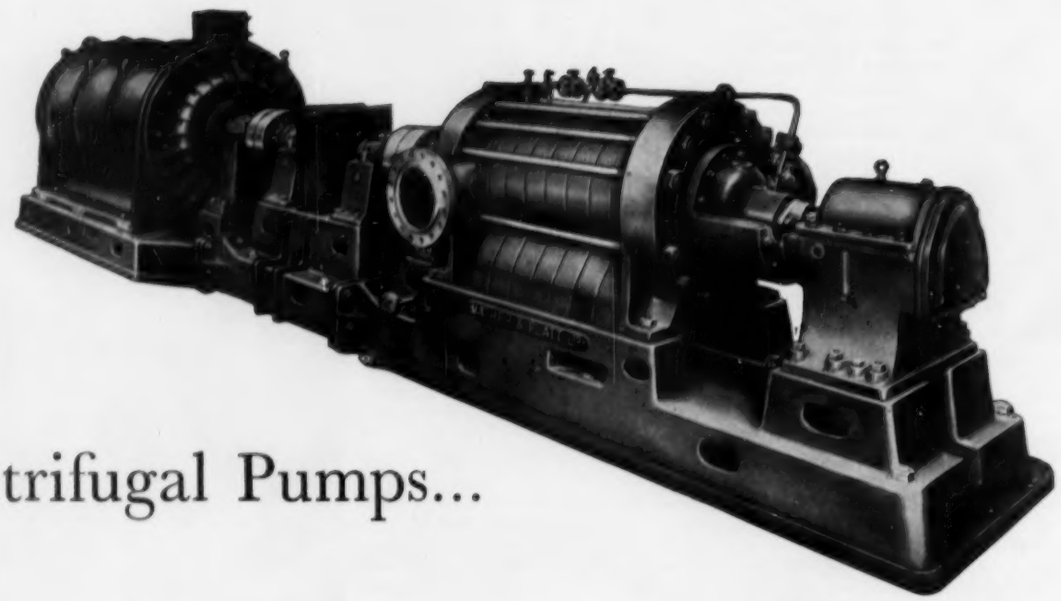

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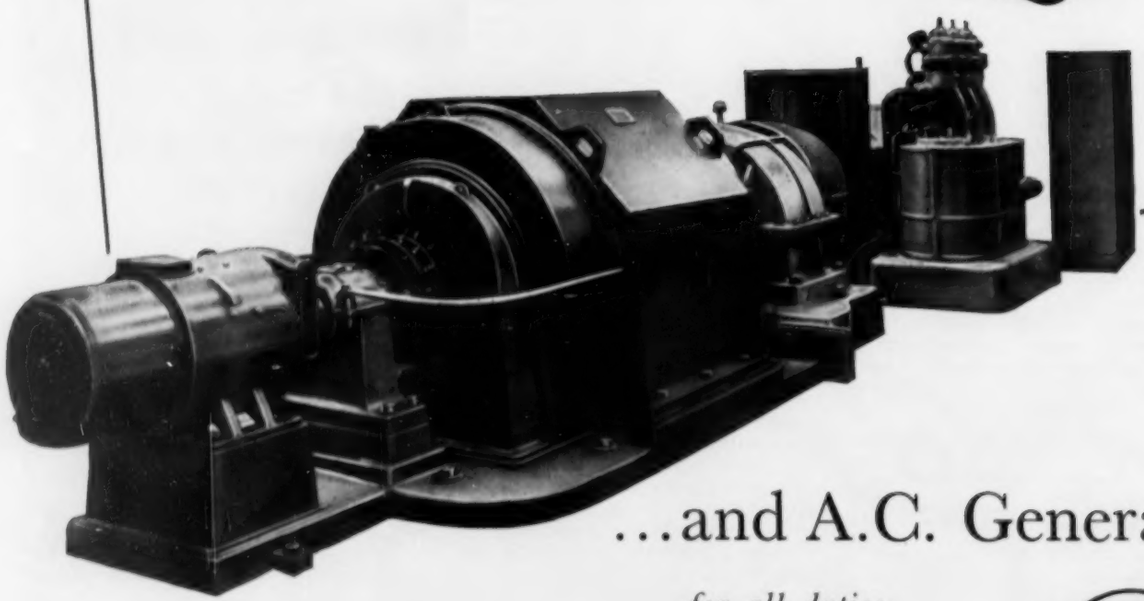

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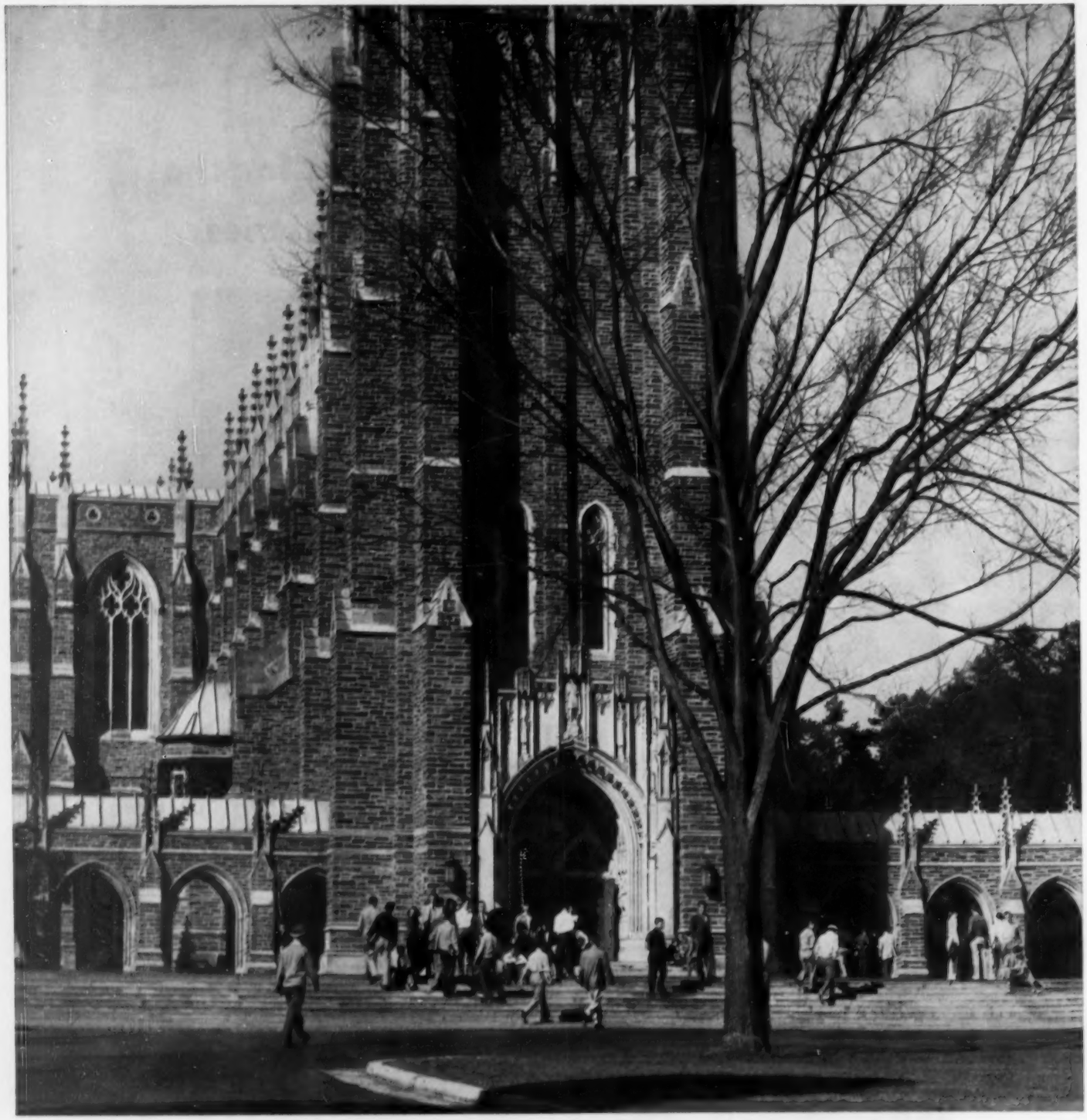

"The nation's need for scientists, engineers, scholars, artists, administrators and specialists of all kinds has grown and continues to multiply. To meet this need is a function of the colleges and universities. A function of even more basic importance is to help develop a nation of informed citizens and to foster, in an expanding student population, the ability and will to achieve increasingly a society that offers freedom, opportunity and dignity to all its members."

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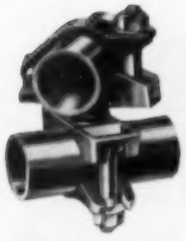

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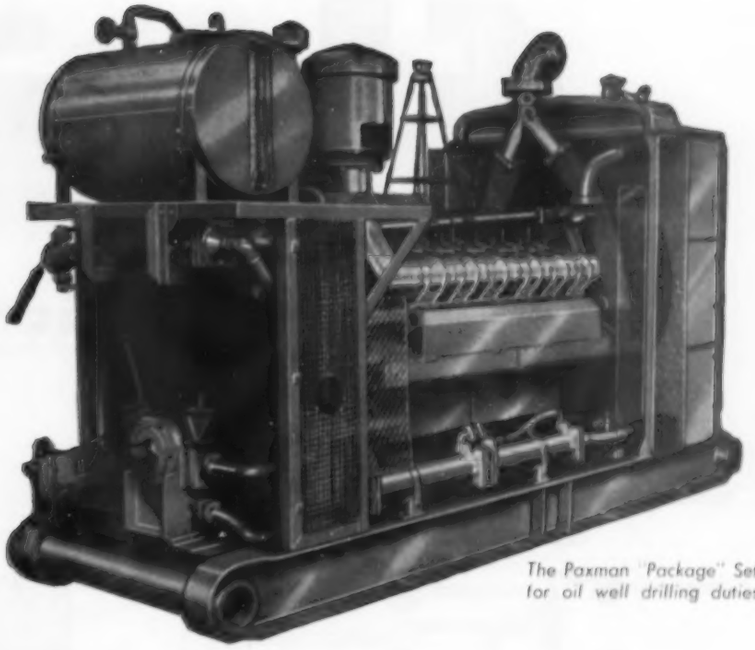

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These engaged in the tough, arduous work of oil well drilling think highly of the Paxman "Package" Set. They like it for its sufferance of rough handling, its ability to keep going under any conditions and its adaptability for almost any type of drilling rig. Paxman Package Sets are available with a horsepower range of 130-665 s.h.p. at the output shaft.

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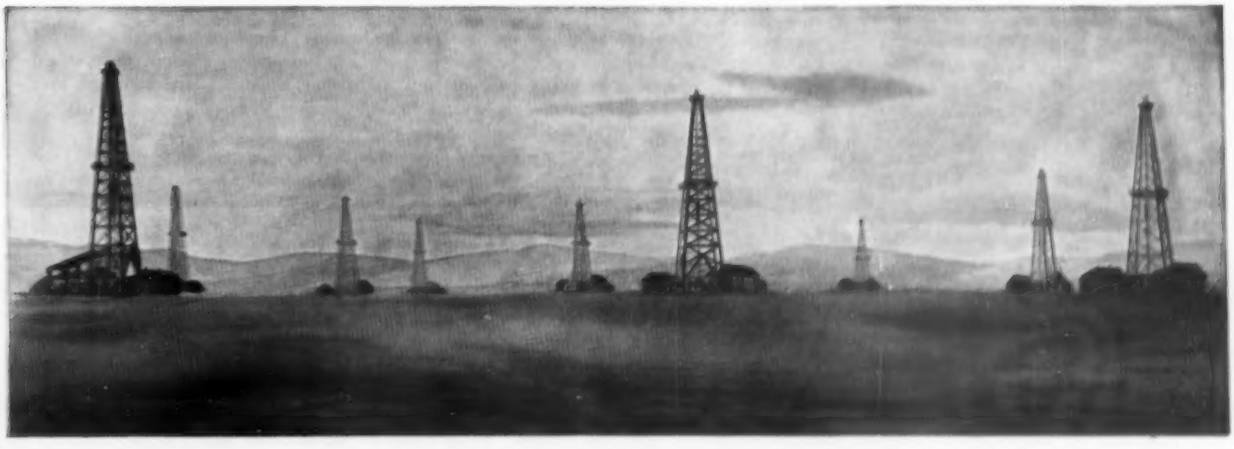
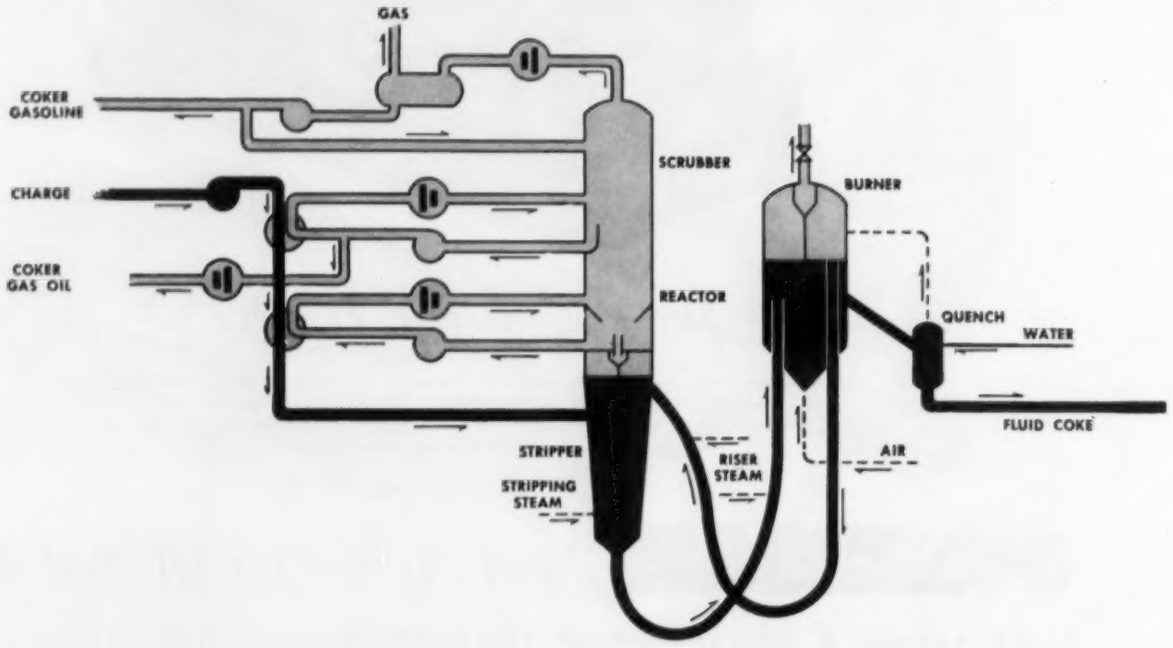


fluid

its production...



IN THIS latest application of the fluidized-solids technique, developed by Esso Research and Engineering, heavy residua and asphalts can be converted to gas, oil and coke.

As shown in the flow diagram above, finely divided coke particles flow between two vessels—a burner and a reactor. In the burner, part of the coke stream is burned to supply the heats for vaporization, cracking and losses. When this hot coke meets the feed in the reactor, coking results and the liquid products are flashed off.

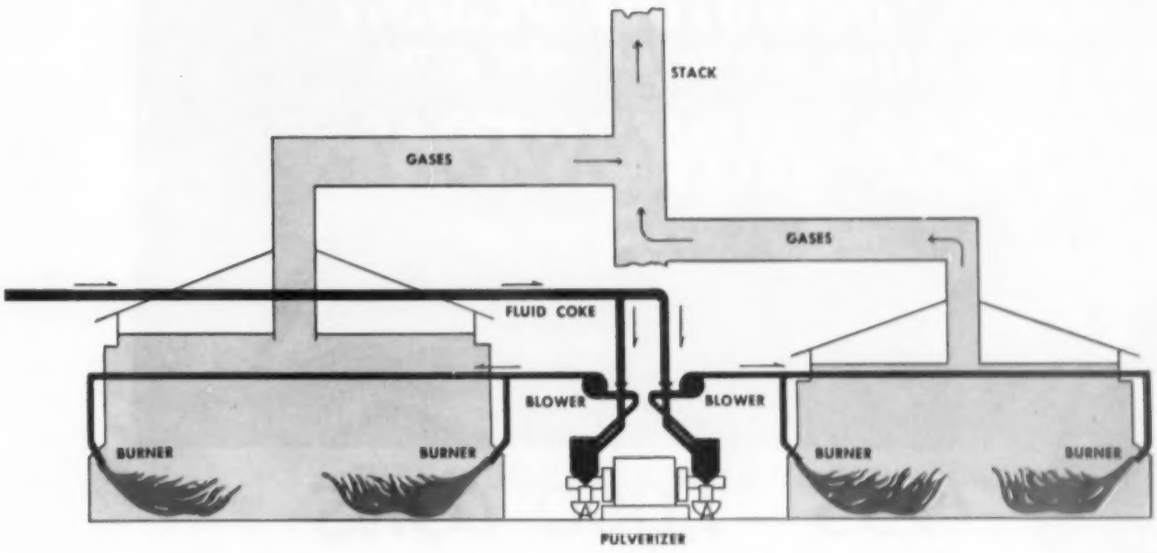
Coke particle size ranges between 75 and 150 microns and the coke itself is a clean, dustless solid. The feed is preheated through two fractionator (scrubber) pump-around systems. In the reactor it contacts the hot coke flowing from the burner. Coke is formed as the fluidized bed moves down into the stripper section where steam removes any remaining volatiles. The stripped coke then flows into the burner where, in contact with air, approximately 5 per cent by weight of the charge is burned. The coke inventory in the unit is fixed and the excess is removed as product coke which is cooled by water spray before flowing to storage.

The vapors from the reactor pass into the scrubber-fractionator section where they are separated into gas, gasoline and gas oil.

FOSTER

coke

...and utilization



THE USE of fluid coke as a fuel is illustrated in the above simplified diagram of two heaters designed by Foster Wheeler for a large oil company. They will supply the heat requirements for the atmospheric and vacuum sections of the highest capacity crude distillation unit in the world, having a combined heat absorption capacity of 336,400,000 btu per hour.

The pulverizers which reduce the particle size of the fluid coke before it is burned in the furnaces, as well as the pulverized coke burners, are also of Foster Wheeler design.

Designs are also available for the burning of fluid coke in steam generators.

Foster Wheeler's experience in the design of equipment for both the *production* and *utilization* of fluid coke will be of value to any process plant interested in converting heavy residua into cracking stock and making effective use of the resulting solid fuel. For further details on this process, or for proposals to meet your specific requirements, write to *Foster Wheeler Corporation, 165 Broadway, New York 6, N. Y.*

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Size range by C.A.E.: Wt. %					
0-10 Microns	4	2	1	1	1
0-20 Microns	9	4	2	2	2
0-30 Microns	16	11	6	5	4
0-40 Microns	28	21	12	10	8
...and a *minimum* of *coarse* particles					
Sieve analysis: Wt. %					
on 100 mesh (149 microns)	0	0	1	1	1
on 140 mesh (104 microns)	1	1	4	6	8
on 200 mesh (74 microns)	4	5	15	22	33

Now Davison has taken the characteristics of High Alumina Catalyst and combined them with the proven advantages of its 13% Alumina Catalyst. This gives you, for the first time, High (25%) Alumina Catalyst with *all* these qualities:

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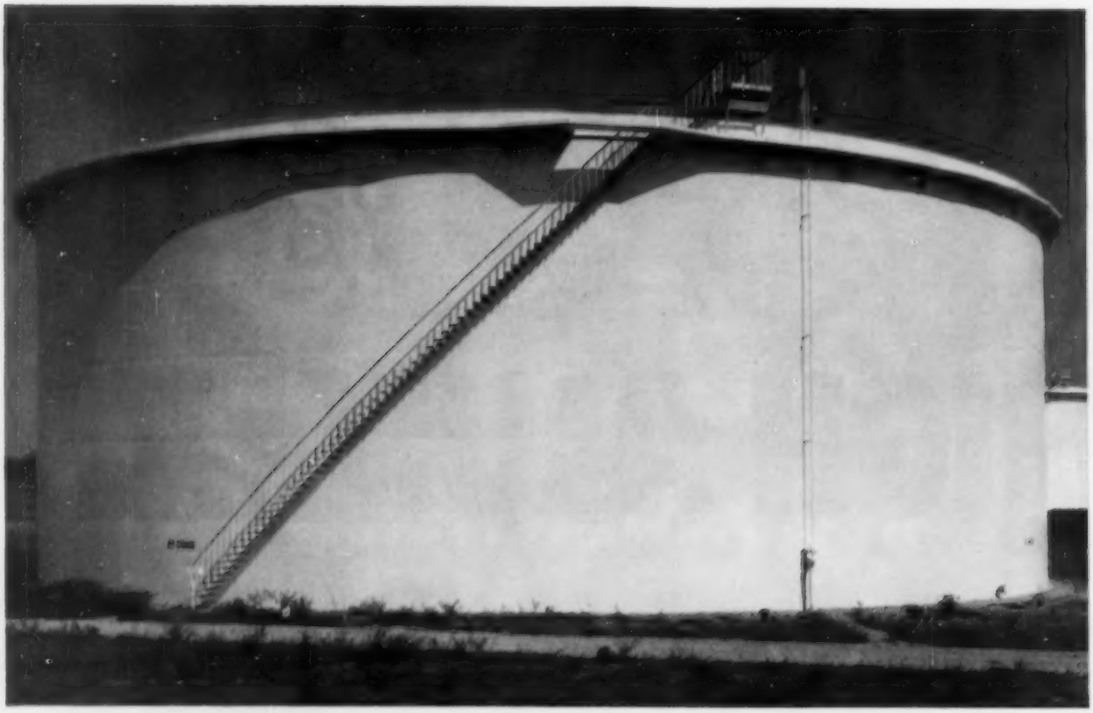

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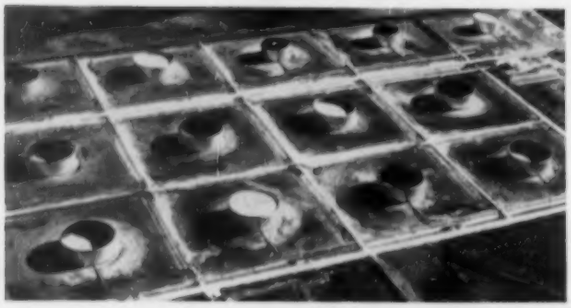
While the Graver Double-Deck Floating Roof Tank is the costliest of our three "floaters," it often proves least expensive in the long run.

Its unusual strength and structural stability make it appropriate wherever lots of snow and ice are encountered. The double-deck roof, consisting of top and bottom deck plate, is divided into liquid-tight compartments. Thus it is practically unsinkable. With the Graver Double-Deck Floating Roof Tank maintenance costs are held to a minimum.

Other popular Graver designs include the Center-Weighted Floating Roof Tank which is unusually stable. We offer also a pan-type floating roof...an economical design suitable to southern climates where snow and ice present no hazard.

Whatever your storage needs it will pay you to contact Graver. Consultation costs you nothing, and competent Conservation Engineers are ready to serve you.

GRAVER ...a conservative design to fit every need



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For over 89 years Socony Mobil has met the lubrication requirements of pioneers in many fields. Aviation's Wright Brothers . . . early car makers . . . the inventor of the Diesel engine are only a few who have called on the Flying Red Horse for specialized lubricants.

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. . . whether your plant is large or small—whether you need a single motor or a complete system.

These highly-trained engineers include specialists with broad experience in the selection and application of electrical and power equipment for all types of industrial use. Their knowledge is available to help *you* get maximum returns from your equipment investment. And their help *costs you nothing*.

Illustrated below are a few of the thousands of Westinghouse products for which this valuable service is available. For details about them—or for specific engineering assistance—please write to us on your company letterhead.

And remember . . . when you're thinking of new electrical or power equipment, it will pay you to contact Westinghouse first.

The Life-Line "A" Motor gives you *better* performance in a *smaller* frame. It incorporates advantages such as longer-lasting insulation, completely drip-proof housing. For full information on other features, write for booklet BC-6154-A.

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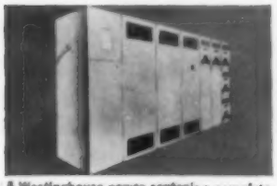
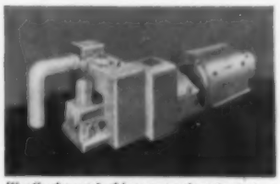
Westinghouse metal-clad switchgear brings you the advantages of "Unitized" construction, complete applicability to your needs, lower installation costs. Write for booklet BC-5282-A on low-voltage switchgear; booklet BC-5306-A on heavy-duty switchgear.



A Westinghouse power center is a completely-coordinated substation that can bring many money-saving advantages to your distribution system. For a discussion of the application of power centers to various needs, request booklet BC-4162.



Westinghouse turbine-generators for industrial applications are available in non-condensing, condensing, and extraction types, with ratings to meet your requirements. For more information, send for a copy of booklet BC-5418.

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M. W. Kellogg has been in the forefront of Fluid Catalytic Cracking from the beginning. Starting early with continuing studies of catalysts, it worked closely with the industry in engineering the fluid principle. M. W. Kellogg's contribution in mechanical engineering made it possible to design units of capacities large enough to meet accelerated demands for higher octanes since World War II. Its long experience in constructing oil refineries enabled M. W. Kellogg to undertake the erecting of these initial units, and the even larger ones in operation today, with full confidence that they would be on stream in minimum time.

An M. W. Kellogg Fluid Catalytic Cracking unit is your guarantee of many predetermined requirements, including throughput capacity, product quality and quantity, utility cost, catalyst loss, and coke-burning capacity. From its experience in engineering and erecting many side-by-side units, M. W. Kellogg originated

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the straight-line Orthoflow* design—which offers many extra economic advantages.

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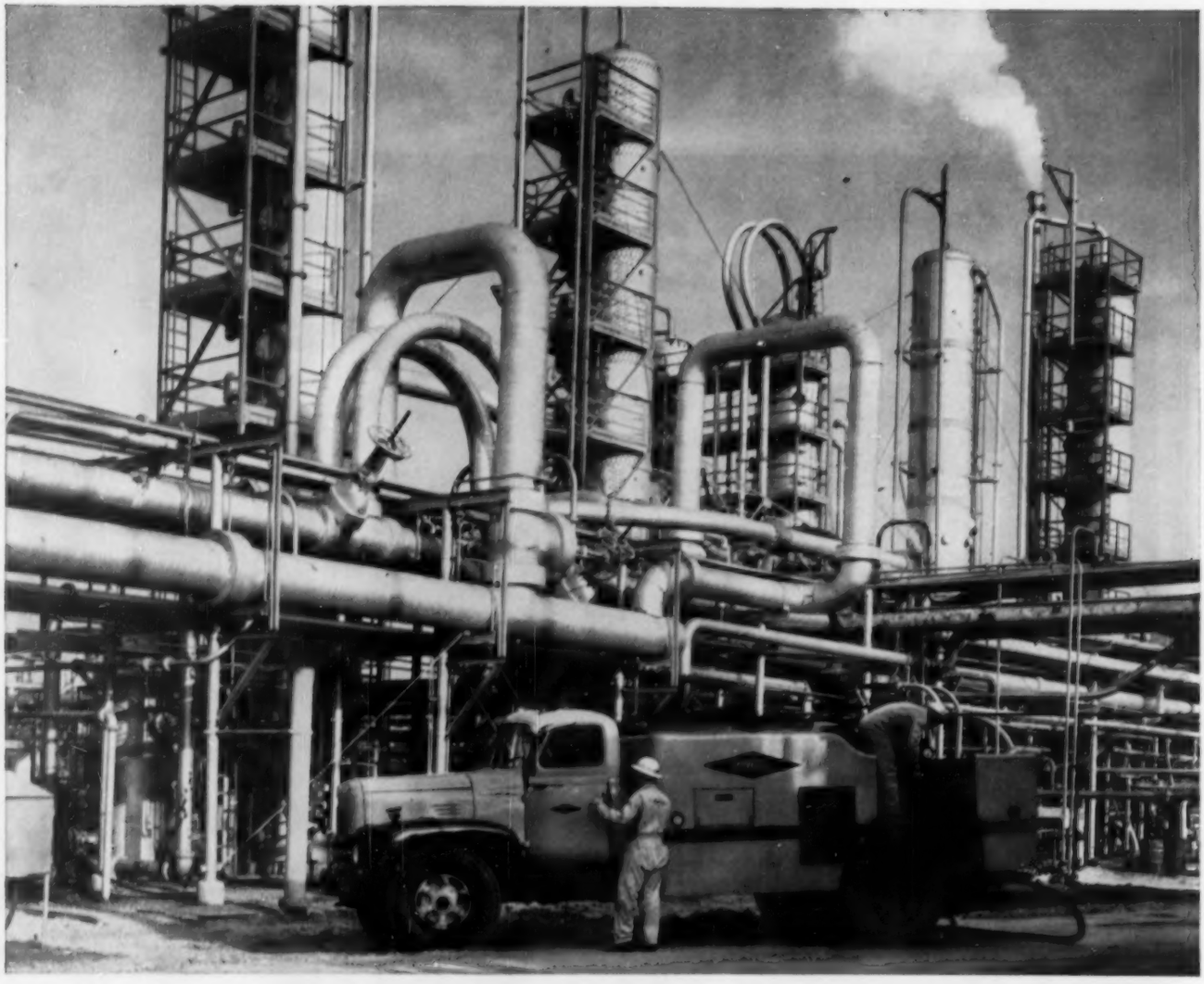

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A refinery operator had to shut down his H_2S stripper bubble cap tower every two months to remove an oily carbonate scale. Each shutdown took seven days, because of the mechanical cleaning methods used, and even then the tower was not thoroughly cleaned.

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You can help to maintain maximum operating efficiency in your plant by arranging for a regular program of Dowell chemical cleaning. For full information, call your nearest Dowell office, or write Dowell Incorporated, Tulsa 1, Oklahoma, Department G-43.

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Protect your high pressure piping system with Watson-Stillman Forged Steel Fittings. Available in carbon, stainless and alloy steels, in Screw-End and Socket-Welding Types to meet your service requirements. Send today for Free Catalogs.

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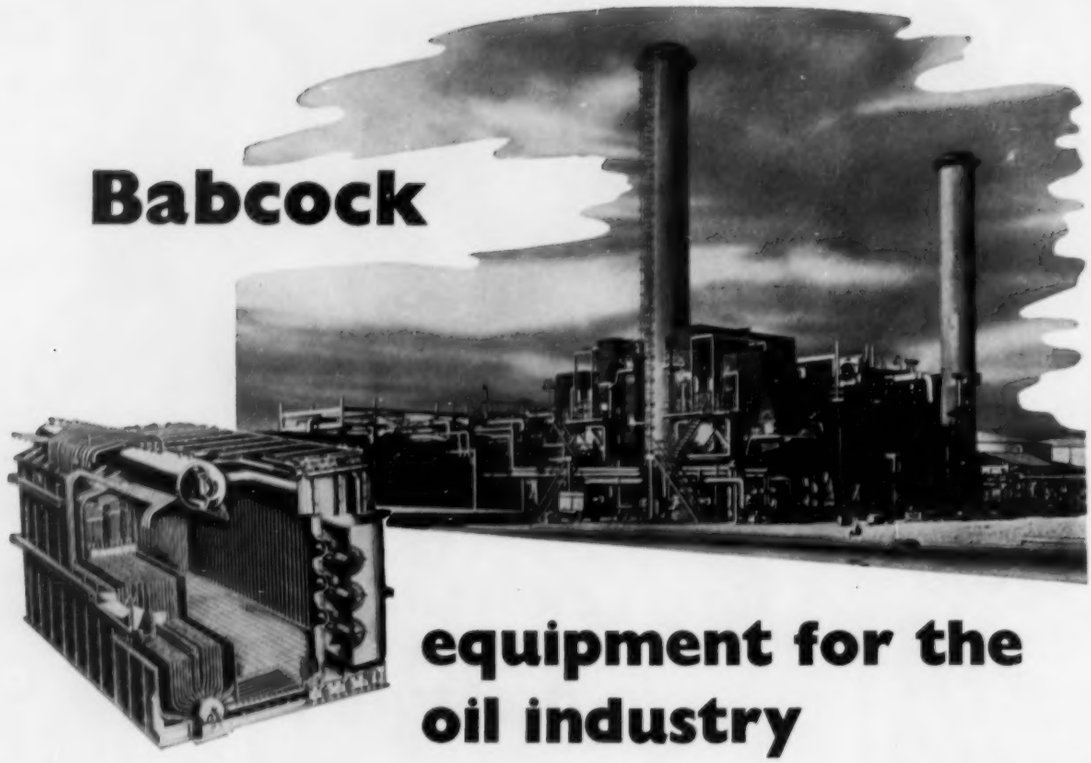

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equipment for the oil industry

A notable trend in the equipment of post-war oil refineries and chemical plants has been the use of "outdoor" boiler installations, in which only the firing and control points are under cover and no boiler-house structure is involved.

The Babcock Integral Furnace boiler*, modern in design, compact, flexible in operation, with quick steaming characteristics and high availability, has proved ideal for this and many other industrial applications. It is available in capacities from 40,000 to over 300,000 lb. steam/hr., for steam conditions up to 900 lb./sq. in. and 900° F, and is supplied for oil, gas or coal firing, singly or in combination.

Babcock & Wilcox Ltd. manufacture a wide range of equipment for the oil and chemical industries, including complete steam raising plants, welded pressure vessels, heat exchangers and plant for waste heat utilization.

* *Ask for Publication 1525/1*

The illustrations show (above) an "outdoor" installation of Babcock Integral Furnace boilers at Shell's Shell Haven Refinery, Essex, England and a sectional view of this type of boiler. (right) A Babcock fusion-welded treating tower prior to despatch from the Company's Renfrew works.

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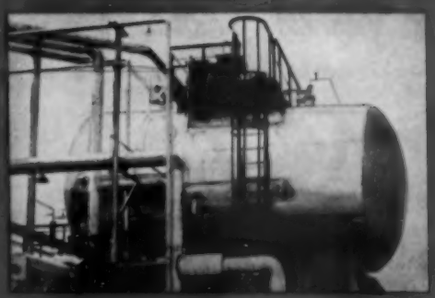
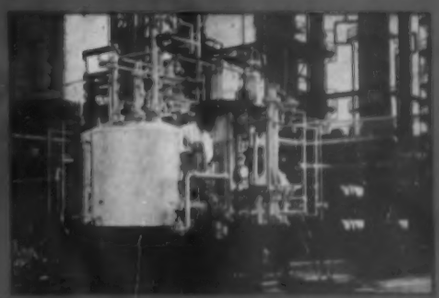
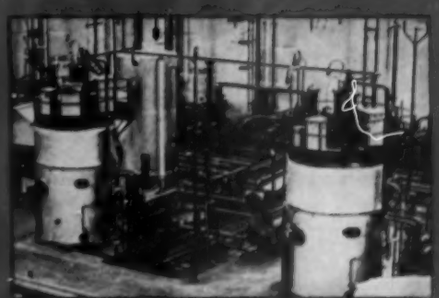


Petreco pioneered electric desalting and is the recognized leader in the field. Petreco offers a wide choice of desalting plant design, horizontal, vertical or spherical, all equally efficient.



Petreco distillate treating offers refiners an improved method for acid-contacting, caustic-scrubbing or doctor-treating. This new process is compact, continuous and automatic.



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THIS MONTH'S COVER

Harold Town of Toronto has made an abstract view of a refinery in the drawing reproduced on this month's cover. The drawing was one of a series made for the *Imperial Oil Review*, house magazine of Imperial Oil Ltd., and is reproduced through the courtesy of the editors of the *Review*.

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211 SERVICE CENTERS – JUST MINUTES AWAY FROM ANY RIG

By P. D. Barton

AUTOMATION
a management viewpoint

Paul D. Barton, chief engineer of the manufacturing department of Sun Oil Co. since March 1947, has spent his entire business life in the petroleum field. He joined Sun in 1934. Over 15 patents have been issued to Mr. Barton, including patents jointly with others on the original hot contact filtration process for the manufacture of lubricating oils. He is the author of the section on the recovery and stabilization of gasoline from refinery and natural gases in "The Science of Petroleum," published by the Oxford University Press (1935) and the author of the section on plant design in "Perry's Chemical Business Handbook" (1954). He was the first president of the California Natural Gasoline Association. He is active on several committees of the American Petroleum Institute, and is a member of the National Society of Professional Engineers.

THERE IS PROBABLY no topic more discussed in industry today than automation, and it is doubtful if there is any that is more misunderstood. This is particularly true of the layman. He is inclined to let his imagination supply many answers, possible or impossible, thus creating his own brand of science fiction.

In the petroleum industry, automation is easily recognized and generally accepted as a logical advancement in the use of automatic controls. Basically, it represents the application of a relatively few mechanical, electrical and hydraulic principles through devices of varying complexity for the accomplishment of a desired result in a continuous or repetitive process.

These devices operate through certain functions of the process itself, such as temperature, pressure, flow, time cycle, physical characteristics and product quality.

Because of this broad use of automatic controls, an oil refinery is perhaps one of the best examples of automation in industry. Crude oil is received through a pipe line and its flow through the refinery is directed by pre-set controls adjusted for the desired processing. Other automatic controls maintain the proper operating conditions within the plant processes and finally deliver the finished product—perhaps even blended and packaged—all with little or no direct manual handling.

In general, the desired result at each step of the refining process could be accomplished by an intelligent operator or laboratory technician, unless his attention were diverted or some new variable entered the picture. Thus, an operator on a hand valve can maintain a fairly constant level or flow rate for a period of time if he has a dependable indicator as a guide, but he is definitely limited as to the number of such manual operations he can carry on simultaneously. In a complex refining unit hundreds of such adjustments can be made simultaneously by instruments.

The story of the development of automatic control in the petroleum industry is the story of the development of the industry itself. Its remarkable growth and highly competitive character taxed to the utmost the ingenuity of its engineers to meet the demands of the modern industrial age for a mobile source of energy, lubricants for almost every conceivable use, and special products in great numbers—and always at the lowest possible price.

It has been possible to meet these enormous de-

mands only by inventing new processes, by designing larger and larger operating units, by combining related processes for increased efficiency, and by integrating operations to balance supply and demand both in the short and long range. In doing so, the growing complexity of these processes has spurred engineers to seek constantly for ways to release plant operators from duties that reduce their freedom of action and thought. Thus, wherever possible, item after item in plant operation has been subjected to automatic or semi-automatic regulation.

At first, most refining processes were operated in "batch" or semi-continuous installations, with the products largely limited by their inherent characteristics.

Instrumentation of these simple processes utilized essentially single-purpose devices designed to reproduce specific manual operations. Their functions could be successfully taken over by an operator upon failure of the device.

Today's complex refining units combine many operations within one coordinated whole. Most operating units in a modern refinery also are related more or less closely with one or more other operating units.

This is where the centralization of control is of real value. The availability of data from the various operations at one location makes it possible for the operator to reach important conclusions from an evaluation of relative facts.

Because of centralized controls, operators of today have time to think, to know their plant, to recognize malfunctions, and to make the adjustments necessary to keep the plant "on the line." And they have a new dignity which goes with the responsibility attached to being entrusted with a multi-million dollar installation.

Management has welcomed automatic control because it makes possible the realization of more and more efficient operation. While confidently making a heavy investment in complex plants and control systems, it will protect that investment by providing an operating staff capable of handling emergencies.

In management's thinking, reduction in operating manpower *per se* is not the goal of automation. The advantages sought, and those to which automatic control already has contributed so much, are greater capacity, higher efficiency of refining units, and lower unit costs of products.

Here is an example of an emergency which probably could not happen again in a hundred years; but it could have wrecked a multi-million dollar plant were it not for the presence of operating personnel.

A furnace was being relit after a partial shutdown for maintenance in one of four boilers. A few seconds after the flame was touched off, a rabbit jumped out of the open furnace door with its fur afire. It ran toward another area of the plant which usually harbors explosive vapors. Fortunately, the shouts of the men at the furnace alerted other plant personnel who headed off the flaming rabbit.

This illustrates the point that when it is necessary for a decision to be made there is still no substitute for the human brain.

While the control system of a modern refinery may be centralized for coordination, it is by no means the comprehensive automatization which is referred to as an example of the "push button" factory. Nor, in the opinion of many refinery engineers, is such an advanced development either practical or desirable.

As a matter of fact, the very nature of the refining industry renders such a development almost impossible of accomplishment. Sparked by the competitive forces which keep the industry dynamic, changes take place with great rapidity.

Changes in technology, in raw materials, in products and product quality; changes in operating capacity caused by fluctuations of supply and demand; changes due to the obsolescence or deterioration of physical plants and equipment—all introduce factors in operating control that can be satisfied only by the decisions and actions of men, *not* machines.

While special emphasis has been given to the part which automatic control has played in the design development of modern refining units, this is not the whole story, by any means.

The benefits of the application of automatic control are felt throughout the whole refinery from the office accounting and billing department to the control laboratory; from safety engineering to pollution abatement; and from blending and packaging to tank gauging.

And the application of control mechanisms is not confined to the refineries. It is found at a high degree of development in all branches of the industry—from the search for new oil fields, drilling, production, transportation, and in the final distribution of products.

The people of the oil industry, from president to office boy, as well as the industry's customers and stockholders, owe more than they know to the engineers who design, build and maintain the instruments and controllers that have made possible our advanced technology.

Those who look superficially at the impact of the broad application of advanced automatic control systems in modern refining practice may conclude that the result has been fewer but better jobs. Actually, the expansion of the industry, made possible largely by the development of these control systems, created many new job opportunities. Statistics show that in the United States today the petroleum refining industry has the highest number of direct employees in its history, with wages and non-wage benefits far in excess of industry in general.

Automation has been referred to as "a second industrial revolution." Actually, because of its gradual development, it might better be described as evolutionary rather than revolutionary.

In addition to spurring the advancement of new processes and technology which have resulted in increased productivity, it has naturally brought about a change in thinking by both management and labor. There is no indication that it has resulted in any serious job dislocations nor, based upon expressions of enlightened leadership among both management and labor, does it pose such a threat today or in the foreseeable future.

On the other hand, the trend to automation promises to provide the answer to the challenge of increasing production to meet future demands. In the refining industry, employees recognize automatic controls as useful tools which have eliminated much manual drudgery, created new job opportunities, up-graded workers' skills and enabled them to improve their individual productivity and job security.

Based upon experience gained in the very highly mechanized petroleum industry, the following principles highlight the viewpoint of management regarding automation:

1) Automation makes possible a high degree of coordination between related parts of an operating unit without limiting the complexity.

2) Automation brings closer together the interdependent functions of management, operation, engineering, quality control, product accounting and plant maintenance.

3) Automation tends to increase the stature of the plant operating personnel as individuals since it makes it possible for them to use their heads more than their hands.

4) Automation is good for both management and the operator. Through centralization of control and the resulting use of advance knowledge gained by the operating team in steering the plant (much as a pilot and navigator steer a ship), management can entrust larger and more valuable installations to the operating staff with confidence. Consequently, the standards of employment in the area of plant operation can be raised and our whole standard of living can likewise be bettered.

AUTOMATION

David M. Boyd, Jr., has a sign near his desk which reads: "LIVIN' CAIN'T BE SIMPLE ENYMORE THEY'S TOO MANY GADGETS." For this condition, Dave is partly responsible. He is recognized in the oil industry as the daddy of the graphic panel and for this was awarded an honorary degree in 1950 by his Alma Mater, *The University of Colorado, from which he was graduated in 1941. His gadgeteering extends to his home and his car—press a button on the car's instrument panel, for example, and the garage door opens. Mr. Boyd has been with Universal Oil Products Co. for the past six and a half years and previously worked with Eastern States Petroleum Co., Blaw-Knox Construction Co. and others. He was head of the instrument application group at the National Laboratories, Oak Ridge, Tenn., on a loan basis to the Atomic Energy Commission from Monsanto Chemical Co.*

Is AUTOMATION the answer?

By D. M. Boyd

WITH THE ADVENT of the word "automation," the field of automatic control has received a terrific boost in recent years. Unfortunately, however, this is a catch word and there is a popular misconception growing on the part of management that automation, or automatic control, is good no matter how it is done. Unfortunately, this is not the case. For a controller to be of maximum value it must be both properly designed and applied.

A very good example of this is the case of the graphic panel that was introduced six years ago at the Rock Island Refining Co. plant at Indianapolis. This plant started a trend in the instrumentation of a process control unit so that today, a large percentage of the new construction is going in with graphic panels. This has been done at the request of management, yet many of the plants that are going in with the graphic panel are failing to take full advantage of the potentialities of this type of control system.

In order to understand this fully it would be well to go back and consider why the first graphic panel was installed at Rock Island. Strange as it may seem, the prime reason for going to the graphic panel design at Rock Island was not to draw a picture on the board. True, the picture has been like a fancy bottle for perfume, it has helped to sell the contents, but as far as the smooth operation of the plant is concerned, there are far more important reasons to consider its use.

Six years ago Rock Island added to its existing refinery a UOP fluid catalytic cracking unit. This unit had to be located 300 feet from the existing control rooms.

This distance caused quite a little concern because of the time lags that would be involved due to the length of the transmission and control lines to and from the control room. A series of tests was run in the laboratory which showed this concern to be based on reality. These tests proved that the over-all control of the unit would be impaired if the controllers had been installed in the control room 300 feet from the unit.

The second problem encountered was the fact that the existing control room was too small to hold the new instruments required for the unit. The existing control board held 25 instruments, while the revised operations of the refinery would require about 80. In order to enlarge the control room, it would be necessary to relocate some pumps and exchangers, this being very costly.

The main problem, then, was to find a different type of instrument that would be smaller in size in order to fit in the available panel space, and would have the added feature that the actual controlling element would be located in the plant itself on some of the faster systems. Yet, this instrument should give the operator complete control of the plant in the control room as far as changing the set point of the controller or placing the controls on hand control.

This was an entirely different type of controller than was then in use, but a suitable controller was found and used. However, by using the smaller controller it was found that with a little care the controllers could be arranged in a simple schematic flow diagram of the plant so that it would be possible to see the effect of one

AUTOMATION

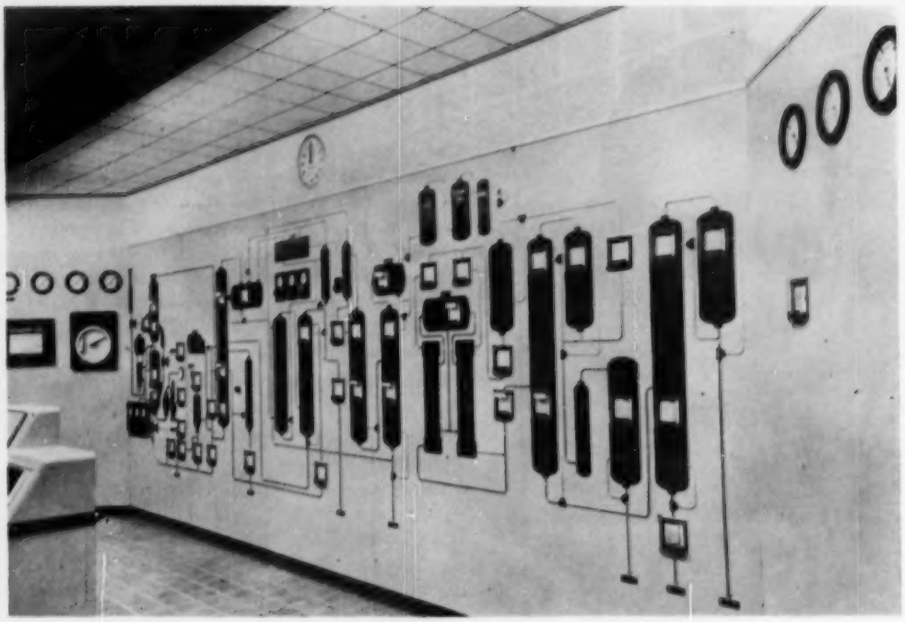


Figure 1: View of a pneumatic graphic control panel.

controller on the other, and their relationship to the whole plant.

As mentioned earlier, this arrangement caught the eye of some managements and there has been quite a swing to the graphic panel type of control system in recent years (Fig. 1). However, far too many people have been blinded by the picture on the board and have not really looked any further into the fundamental reasons for considering the graphic panel. The result is that far too many panels have gone in with controllers for fast systems, such as flow, located on the back of the board instead of at the point of control. More recent tests have shown that even six feet of tubing between the controller and the valve will have a marked effect on the over-all performance of the controller.

The other mistake that is now being made is trying to make the graphic panel a detailed flow chart of the plant. This proves to have two disadvantages. One, the additional lines, due to heat exchange and cross connections on pumps, tend to confuse the picture rather than help to clarify it. Second, the panel size becomes almost as large as one using the old large case instruments, even though smaller instruments are used for control.

It should be remembered that a good operator is like a man playing an organ: he knows where to reach for a given instrument in the process without having to look for it. The person most helped by the picture on the graphic panel is the plant manager, and he is not concerned with heat exchangers or cross connections on the pumps. It is best, therefore, to leave auxiliary equipment such as heat exchangers and pumps off the graphic panel unless they are specifically involved in the control, as these account for most of the changes that are made in the plant after it is built. By leaving them off, it is not necessary to change the graphic picture every time a minor change is made in the plant.

At the present time the field of process control is entering a new phase: electronic control.

Again the reasons for going to this form of control are easily misinterpreted. When most people think of electronics, they think of units capable of performing at the speed of light. Therefore, the main reason for considering the use of electronic controllers is one of speed. Actually, tests have shown the complete electronic control system to be no faster than the pneumatic controllers which are valve mounted as in the graphic panel.[1] The main reason for this is that the controller still has to move the control valve in order to perform its control functions. The air pilot valves on the power relays of the present electronic controllers do not have the air handling capacity of some of the pneumatic instruments available on the market today.

Yet, in spite of the fact that electronic controllers do not show any improvement as far as speed of response is concerned, they do give far superior over-all control of the unit. It was found, for instance, by using special recording instruments, that the top tower temperature controller on a feed splitter was being held to plus or minus 1/50° out of 200°F (Fig. 3). The heater firing controls were being held to 15/100 of a degree F out of 900° F (Fig. 4). In other words, the temperature controllers were holding to about one part in 10,000! This control performance had never been equaled before on similar units employing pneumatic controllers.

In order to understand the reason for this superior performance, it is best to look at some of the fundamentals of controller operation. Until recently, the majority of controllers in use were of the proportional plus reset type. This meant that they biased the signal to the control valve based on two factors. The proportional control function is, as its name implies, proportional to the error that exists between the measured variable and the desired value set by the operator. The so-called reset function is actually an integration with respect to time of the error that exists between the two values. The longer that an error exists, the greater will be the corrective action sent to the valve.

A third control function is being incorporated into many controllers today where more accurate control is desired. This is the so-called derivative function, which can play a vital role in the control of temperature when properly used. It is based on the rate at which the error is changing. If the error suddenly increases, a much greater correction will be made to the control valve than if the change occurs slowly.

The normal design of a temperature controller of the thermocouple type has not

[1] D. M. Boyd, *Why Electronic Process Control?* presented at ISA meeting, Philadelphia, Pa., Sept. 15, 1954.

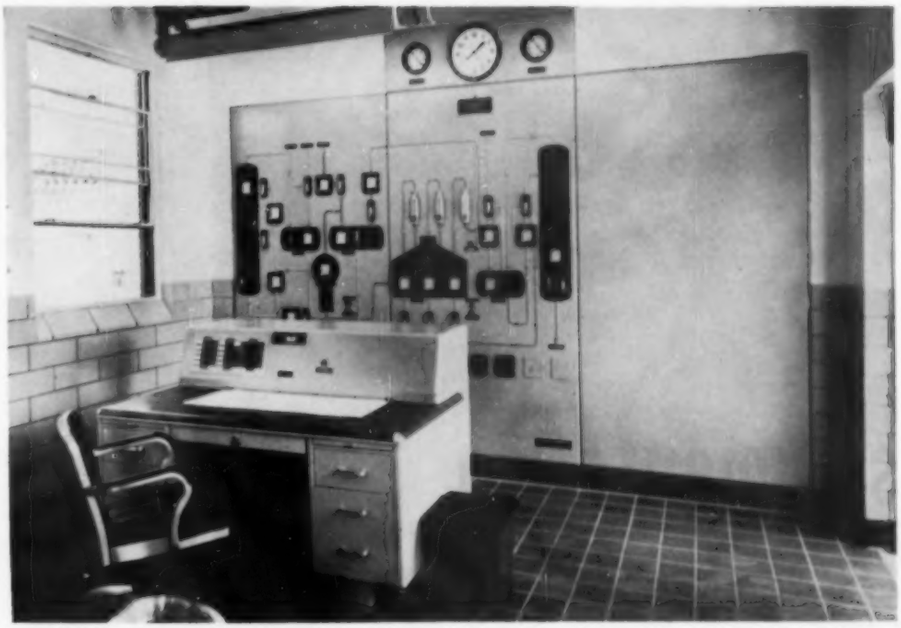


Figure 2: View of the electronic graphic control panel at the Rock Island Refining Co. plant at Indianapolis.

permitted optimum use of the derivative function because there usually is a mechanical means of balancing the potentiometer circuit, in order to convert the electrical impulse to a pneumatic control impulse and to provide a record. If the process temperature changes slowly, the error may not be detected by the mechanical balancing mechanism until it is fairly large. Then the controller will suddenly "catch up," causing the derivative unit to sense a sudden change and make a large correction to the valve, which could upset the plant.

With the electronic control system, it is not necessary to interpose the mechanical balancing step to convert the electrical thermocouple signal to a control function. The electrical control signal has greater sensitivity, which reflects a much truer picture of any rate of change in the process.

The installation at the Rock Island plant has shown the value of this feature. The derivative settings have been adjusted to rates that were never practical before on similar applications because of the distorted picture that was obtained of the rate of change in the process. By being able to use greater derivative action and by having greater sensitivity in the controller, it has been possible to correct even very small temperature changes before they became noticeable on the recorder.

As stated earlier, the process control industry has available to it controllers that are holding a Platforming unit to one part in 10,000. These controls could be applied to a whole refinery with the same results. Then management would be faced with an interesting situation. The controllers are holding the process variable within one part in 10,000 of the set points and yet the actual set points are probably not known within 2 percent of what they should be for optimum dollar yield in the refinery. In the future, it appears that with the use of computer techniques it should be possible to determine these set points to a much greater degree of accuracy and profit to the refiner.

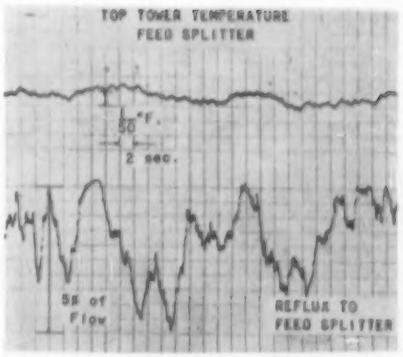
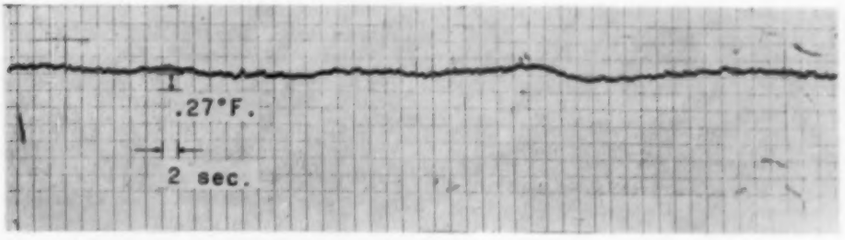


Figure 3: High speed recording of electronic temperature controller on feed splitter at Rock Island.

Figure 4: High speed recording of electronic temperature controller on Platformer heater firing controls.



In conclusion, it should be pointed out that process control has made very great advances in the past five years and promises to make even greater advances in the next five provided that management recognizes the need for the improvement and acts accordingly. "Automation" in the process industries is a very promising field and can lead to great financial benefits to the refiner if properly engineered. However, if poorly engineered it can lead to disillusionment and disappointment.

AUTOMATION

electronic instrumentation

The Atlantic Refining Company's Catformer at Port Arthur, Texas, is instrumented with an electronic control system which has given satisfactory performance since the unit went on stream in August 1954.

By F. C. Somers and R. C. Fuhs*

DURING THE preliminary stages of the design of the Atlantic Catformer at Atreco, Texas, Atlantic's engineering and construction department decided that recent developments in instruments and controls, particularly along electronic lines, justified a reappraisal of Atlantic's instrument practices and a thorough evaluation of available equipment of both the pneumatic and electronic types. The reappraisal indicated that a first-class, thoroughly modern installation should satisfy these requirements:

(a) Operate dependably and accurately.

(b) Offer low first cost. As the number of instruments and controls has increased, the cost of the equipment and interconnections has required closer scrutiny. The skilled labor required for the tubing work between pneumatic transmitters and controllers, plus the costs of such auxiliaries as air compressors, filters and driers, indicated there should be less costly ways of doing the job.

(c) Require minimum size control house. That the trend in control houses is strongly in the direction of larger and more elaborate buildings is apparent to all. Unfortunately, the consequences in terms of overall cost of the instrument installation are not always appreciated.

(d) Require minimum operating personnel. Some instrument panels cover so much space that they require the attention of several operators.

(e) Require less maintenance and be easier to maintain when maintenance is required.

(f) Be adaptable to incorporating probable future developments in the field of automation.

A careful evaluation of available instruments and controls led to the conclusion that an electronic instrument system fulfilled the above requirements more nearly than a pneumatic system. Although operating experience was practically non-existent at the time, the marked reduction in moving parts and the inherent accuracy and absence of time lag in electrical measurements led to the conclusion that the operation of an electronic system was potentially more dependable, as well as more accurate. Economic studies indicated the installed cost of the electronic system was about 12 percent less than for an equivalent pneumatic system. Equipment costs were not significantly different. Differences in installation costs, and particularly the differences in the cost of electric wiring versus pneumatic tubing, accounted for much of the saving. A number of possible control house layouts using the various types of instruments were investigated, and it was concluded that electronic instruments in a console arrangement would result in a minimum size control house.

Employing electronic instruments in a console arrangement produces an extremely compact arrangement with all instruments and controls readily visible and accessible to a single operator. As can be seen from Figure 3, the console is not much larger than a conventional desk. Such compactness and accessibility is most desirable when operating the plant with a minimum number of shift operators.

The fact that electronic instrument equipment has few moving parts, none of which is delicate, points in the direction of less maintenance. The "plug-in" feature of electronic instruments and controllers, in conjunction with the fact that control action can be preset to desired values without cut and try adjustments after installation, makes interchanging units a simple matter. Thus most maintenance work can be performed under favorable shop conditions.

Virtually all foreseeable future advancements, such as automatic data gathering systems, are based on converting the measured quantities to electrical units and from this standpoint, the electronic equipment is particularly advantageous.

The electronic system appeared superior on all points, but there was not sufficient

*Engineering and Construction Department, The Atlantic Refining Company.

Frank Colton Somers, manager, engineering research division, engineering and construction department of the Atlantic Refining Co., accepted his present position in October 1953 after ten years with the Standard Oil Development Co. Mr. Somers was graduated from Duke University with a B.S. in electrical engineering in 1936. In 1938 he was awarded a Master's Degree in the same field by the Massachusetts Institute of Technology. Prior to his connection with Standard Oil, Mr. Somers had electrical engineering experience with the Communication Development Company, Camden, N. J., and the Lago Oil and Transport Co. in Aruba, Curacao, Dutch West Indies.

•

Richard Charles Fuhs, junior engineering assistant, engineering research division, engineering and construction department, joined the Atlantic Refining Co. in March 1954 in his present position. He is a graduate of Villanova University in suburban Philadelphia, where he obtained his B.S. in electrical engineering in 1950. He served in the U.S. Navy during World War II. Following his graduation from college, he worked in the U.S. Naval Air Experimental Station as an electrical engineer for four years.

operating experience available to substantiate the conclusions. However, the potential advantages appeared great enough to justify pioneering a full-scale installation. Accordingly, Atlantic's engineers, in conjunction with the H. K. Ferguson Co., proceeded with the design and installation of an electronic instrument and control system for the Catformer at Atreco.

The electronic system employed is the Swartwout Autronic Control system. The basic principle of this system is the conversion of a measured variable to a 0 to 0.5 volt, 60 cycle, AC signal in the primary element or transmitter which is mounted near the measuring point. This signal voltage is transmitted to the recorder or indicator in the recording systems, or to the recorder and controller in the control systems. The controller converts the difference between the transmitter signal and the set point signal to direct current. This current is transmitted through the manual-automatic selector switch, called the manual control, to the electric to pneumatic transducer, called the power relay. The air from the power relay actuates any standard diaphragm valve. The recorders, controllers, and manual controls are located in the central control house, while the power relay is mounted near its control valve. A block diagram of a control system is shown in Figure 4.

The mechanical design of instruments is a factor that is often overshadowed by considerations of operating principles and potential performance. Actually, sound mechanical design is the most fundamental consideration of all. It is the basic requirement for peak performance, stable operation, and reasonable maintenance. In selecting instrument equipment for this project, mechanical design received the consideration it deserves, and it is believed that the equipment used is outstanding in this respect. Figure 5 shows a transmitter with and without cover, while Figure 6 shows a power relay with and without its enclosure cover. Both devices are mounted in substantial cast enclosures approved for use in Class I, Group D, Division 1 location. Attention is directed to the small number of parts and the rugged construction throughout.

Both recorder and controller are flush mounted, miniature, "plug-in" type, designed to require minimum panel space. A recorder or controller consists of a mounting frame which is permanently fastened to the panel with the recorder or controller proper being assembled as a removable chassis which plugs into the mounting frame. All external connections are made to a terminal strip at the rear of the mounting frames. Connections from the mounting frame to the removable chassis are made through a plug and socket arrangement very much like the plug and socket of the familiar radio tube. This construction permits the controller and recorder to be easily removed from its mounting frame without disturbing any external connections. Figure 7, a photograph of the controller partially removed from the mounting frame, shows the "plug-in" socket of the mounting frame and the controller adjustments which are readily accessible from the front of the panel. A side and underside view of the controller chassis, Figure 8, with the dust proof case removed, points out the neat arrangement of components which permits simple test and maintenance. Two views of the recorder are shown in Figure 9.

The absence of delicate moving parts in both the recorder and controller is in contrast to constructions commonly encountered in other types of instruments. Figure 10 is a photograph of the manual control unit. The unit is in its own enclosure and may be removed for repairs and replaced without disturbing the controller.

General Layout of the Plant: A general view of the Catformer is shown in Figure 1. The fractionating section is shown in the foreground with the control house in the righthand corner. In the background may be seen, from left to right, the compressor house, the reactors, and furnaces. A 12-foot wide accessway running the length of the plant is located between the fractionating section and compressor house. The plot is approximately 200 feet long by 120 feet wide. The instruments and controllers are centralized in the control house. An overhead metal cable way extending from the control house down the length of the accessway between the compressor house and the fractionation section carries the interconnecting wiring.

Figure 1: General view of Atlantic's 8,000 b/d Catformer at Atreco.

Figure 2: The control house.

Figure 3: Front view of the console.

A complete list of the instrumentation installed is as follows:

1) Twenty recording systems, consisting of nine flows, six pressures, and five temperatures. (Electronic transmitters and recorders).

2) Fourteen controlling systems, consisting of six flows, five pressures and three temperatures. (Electronic transmitters, recorders, and controllers).

3) Forty thermocouple points. (Read on an electronic-type indicating potentiometer).

4) Four liquid level indicators and controllers. (Pneumatic type).

5) Two liquid level controllers. (Pneumatic controllers, locally mounted).

6) Two high level alarms. (Triggered by float-actuated switches).

7) The operation of all compressors and pump drives is monitored by running lights.

8) A cooling tower low water level and gas alarm.

9) Speed controllers on the four compressors. (Pneumatic, locally mounted). With respect to items 4 and 5, pneumatic level controllers were selected because a suitable electronic instrument was not available. Two of these level controllers are "blind" controllers, while four have the level indicated on the console. These four levels are the only signals pneumatically transmitted to the control house. Pneumatic speed controllers were chosen because they are completely locally mounted instruments and electrical transmission and control was not considered necessary.

All instrumentation, with the exception of the compressor speed controllers, is mounted in a console type panel located in the control house. A photograph of the console is shown in Figure 3. The panel instruments are the minature, "plug-in" type and lend themselves to console arrangement. The console arrangement is something of a departure from the currently popular graphic panel arrangement. Graphic panels may have some initial advantages in training and familiarizing the operators with the plant, but these advantages are only temporary at best. The higher first cost, excess building space requirements, and general lack of convenience in operation as compared to a console are disadvantages that continue for the life of the plant. A console has the advantages that all controls are visible to the operator at a glance, and it can be fabricated, tested, and shipped as a complete unit. This latter feature greatly eases the installation problems, since only a comparatively simple field recheck is necessary.

Although it is often overlooked when estimates and comparisons are made, the cost of the control house is a large part of the total instrumentation investment. As an example of the economies that are possible by a combination of miniature instruments in a console arrangement, the control house for this plant, which is pictured in Figure 2, is only 14 by 25 feet inside. The area of this house is only 350 square feet as compared to 900 square feet required for another recently constructed Catformer using standard size pneumatic instruments.

Normal instrument power system: The console presents a load on the 115-volt system of approximately 1,500 VA. This power is fed by one circuit, but in the console it is subdivided into two main groups.

1) The instruments, which are fed through a 2,000-volt amp. constant voltage transformer.

2) Accessory equipment (clock, running lights, etc.), which is fed directly from the line.

The constant voltage transformer serves as an isolating transformer, since the instruments have one side of their power circuit grounded and are being fed from a 115-volt ungrounded system. The instruments are the null balance type and are not affected by nominal voltage variations; hence the constant voltage feature is not absolutely essential.

The power supply circuit, along with all the power and signal wiring from the transmitters and power relays, is brought to the console through a single metal cableway. (See Figure 11). All circuits terminate at terminal blocks in distribution boxes located in the console.

The controllers and recorders have internal circuit protection; however, additional protection is required to isolate separate systems from the main feeder. In the recording system, the circuit protection is arranged to isolate both the recorder and its associated transmitter in case of failure of either. The protection for the control system removes the transmitter, recorder, and controller in case of failure of either, and separate circuit protection is provided for the manual control and power relay. This permits the valve to be operated manually from the control house in case of failure in either the transmitter, recorder, or controller. It is also possible to have a record of the controller variable while on by-pass control in case of failure in the power relay.

Accessible from the rear of the console are individual mercury-type control power switches for each recorder and its transmitter, each controller and its recorder and transmitter, and each manual controller. The mercury switches have one disadvantage—if the console is accidentally jarred, the mercury contact is momentarily broken. This brief interruption of power does not upset the control action, but it does produce "pips" on the recording charts.

Emergency instrument power system: Although the plant is not designed to operate in cases of complete electrical power failure, it was considered necessary to provide the instruments with emergency power to protect against an abrupt loss of control. Rather exacting emergency power requirements were imposed by the instrument manufacturer to insure continuous operation of the instruments at their guaranteed accuracy. These special requirements were:

1) A maximum of three-second interruptions.

2) Supply to have a plus or minus 3-cycle per second frequency regulation. (The voltage regulation was not critical, since power is fed through a constant voltage transformer.)

An existing emergency power system supplied by a 20-kw steam turbine was available in a nearby process unit. Test indicated this turbine generator required five to ten seconds to come from rest and deliver rated voltage. To meet the three-second requirement, it was necessary to install a special emergency system for instrument and control power. This auxiliary unit is continuously operating and capable of delivering power immediately when called upon. The installation consists of an AC motor, an AC generator, a DC unit (motor or generator), all on the same shaft, a storage battery, and a control cabinet. The unit rotates continuously. Normally the AC motor drives the AC generator and the DC unit, which acts as a generator to maintain the battery in a fully charged condition. If power fails, the battery supplies power to the DC unit, which acts as a motor to drive the AC generator.

The battery will supply the load of the console for about a half hour. To conserve the battery and to permit emergency operation for longer than one-half hour, the instrument system load is transferred to the previously-mentioned 20-kw turbine generator as soon as it is up to rated speed and voltage.

Experience indicates that the emergency power requirements imposed were more exacting than necessary for this plant. These requirements may be justified for continuous operation at the guaranteed accuracy; however, since the purpose of this plant's emergency system is only to bring the unit to a gradual shutdown, extreme accuracy is not required. Field tests, plus an unexpected complete power failure, indicate that instrument power may be off for up to 10 seconds and still maintain satisfactory control for making an orderly shutdown of the unit.

Interconnecting Wire: A single metal cableway carries all wiring between console, transmitters, thermocouples, and power relays. It is mounted on pipe supports and is "T" shaped in its layout. One leg runs the entire length of the plant, and from it another leg is sent through the reactor-furnace section. A photograph of the cableway from the unit to the control house is shown as Figure 12. This type of construction was chosen over conduit for its initial economy of material and labor and its future flexibility. Most processes undergo expansion and refinements over the years, and the instrumentation must keep pace. The cableway system greatly simplifies the problem of relocating or adding instruments. Except for the control house, which has a special cableway, the cableway has a cross section of four by six inches. It is

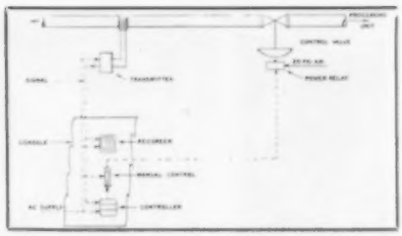


Figure 4: Block diagram of typical flow control system.

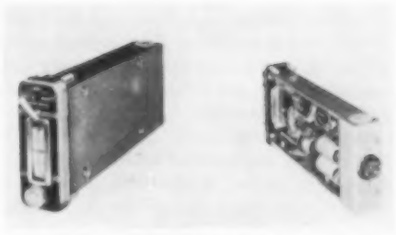


Figure 10: Front view of manual control and rear view with cover plate removed.

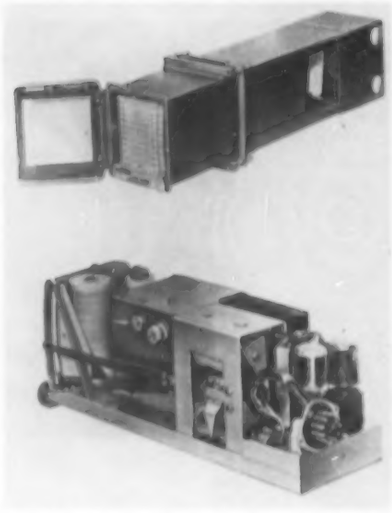


Figure 9: Recorder partially removed from mounting frame and rear view of recorder chassis.

made of 16-gauge hot dipped galvanized iron. Its U-shaped channel lid is fastened to the duct with sheet metal screws and sealed with a Neoprene gasket. Branch connections from the cableway system to the field transmitters, power relays, and thermocouples are made with rigid steel conduit. A seal fitting is provided in all conduits at the end away from the duct. A typical installation is shown in Figure 13.

All wiring consists of multiconductor cables. Except for thermocouple leads, the insulation and jackets are of the thermoplastic type. The transmitters use a special four-conductor cable made up of two shielded #22 AWG stranded and twisted wires for the signal leads and two unshielded #20 AWG stranded and twisted wires for the power to the transmitter. The power relay cables are made up of two unshielded stranded #20 wires. This wiring is adequate for installations up to 1,000 feet in length. Thermocouple leads are iron-constantan, #16 AWG, with thermoplastic insulation, and cabled in pairs with a cotton lacquer jacket and a metal braid over-all. Instead of providing spare conductors in each cable, several spare cables of each of the above types were included in the original installation. These spare cables extend the full length of the duct system and thus may be picked up at any point desired.

The transmitters and power relays have explosion-proof enclosures approved for Class I, Group D, Division 1 locations. There is little difference between the installation of this type of equipment and pneumatic equipment. The transmitter should be mounted as close as possible to the measuring take-off point for accuracy and rapid response, yet mounted at convenient height for maintenance and calibration. The pressure and differential pressure transmitters can be calibrated by hanging dead weights from a point at the rear of the transmitter lever assembly. (See Figure 15). To take advantage of this feature, the transmitter must be mounted upright and with no obstruction at least 18 inches below it. Transmitters are equipped with their own dampening device, which permits the transmitter to be mounted in areas of normal vibration generally found in refinery work without special precautions. In locations subject to unusual vibration, it has been found necessary to provide separate and more rigid mounting, rubber vibration absorbers be-

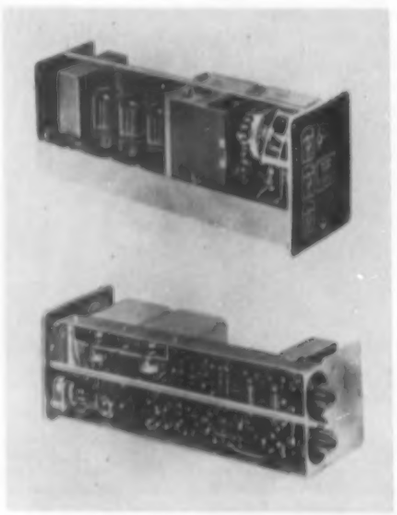


Figure 8: Side and bottom view of controller chassis.

Figure 5: Pressure transmitter with and without cover.

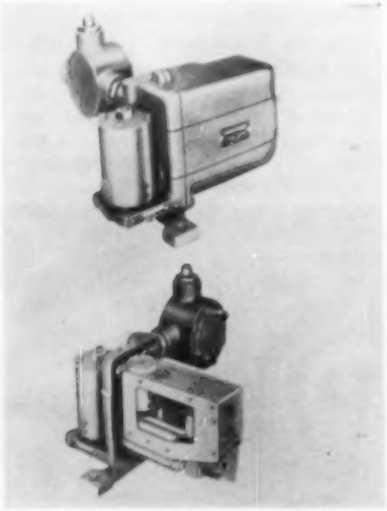


Figure 6: Power relay with and without cover.

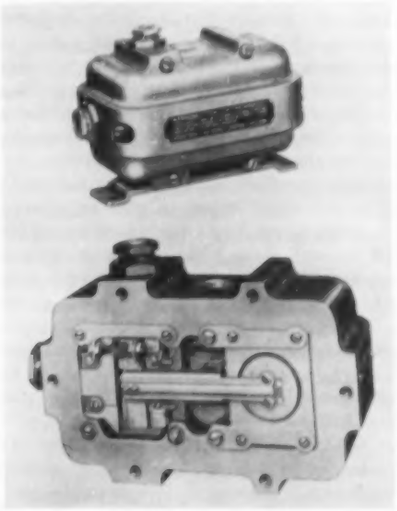


Figure 7: Controller partially removed from mounting frame.

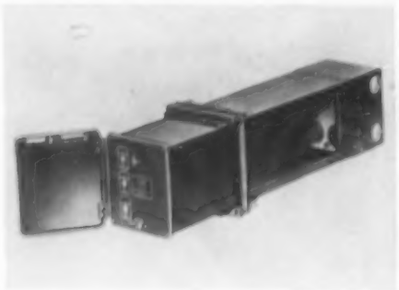
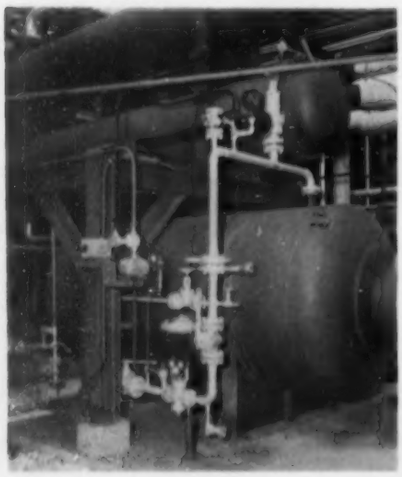


Figure 11: Rear view of console showing wiring duct on control house wall.

Figure 12: Interconnecting wiring duct between unit and control house.

Figure 13: Typical remote installation showing transmitter power relay and diaphragm-operated control valve.



tween the mounting bracket and the transmitter, and a section of flexible hose in the metering lines. Power relays are not equipped with any internal dampening and are rigidly mounted.

As mentioned above, this plant has 15 flow transmitters, all of which are the DP type with teflon diaphragms. Teflon was selected over steel because of its superior corrosion resistance and characteristic minimum zero drift. The diaphragms for the pressure transmitters are stainless steel.

The primary element for a temperature recorder or controlling system may be any thermocouple or resistance element. This installation employs iron-constantan thermocouples, with a thermocouple-converter located in the console. The thermocouple-converter is designed to convert the thermocouple DC millivoltage to the base 0-0.5 v, 60 cycle AC signal to feed other instruments in the system. The thermocouple-converter has both adjustable zero suppression and adjustable range. The field mounted primary elements as installed here have one shortcoming—they are blind transmitters; that is, they do not provide a local indication of the measured variable. However, this problem has since been overcome and an instrument for a local reading is now available.

Operation Start-Up: The performance of the instrument installation during start-up and subsequent operation has exceeded expectations. As with all new developments, a period of finding and eliminating the "bugs" was anticipated, but in this case the "bugs" never materialized. The start-up of the plant was completely free of instrument problems. Operations to date have been characterized by the same performance and it is apparent that there are no problems peculiar to this electronic system.

During start-up, the optimum settings for proportional band, automatic reset, and rate action were found by the usual "cut and try" procedure. The standard controller has a range of 2 to 200 percent proportional band, .03 to 20 repeats per minute automatic reset action, and .05 to 8 minutes rate action. Standard controllers are used for the three temperature controls, while flow and pressure controllers have standard proportional band with a fast acting automatic reset action (.03 to 240 repeats per minute), but no rate action. The adjustments made during start-up clearly indicated that faster rate times are possible with the electronic system than with a pneumatic system. Although direct comparisons were not made, it is estimated, based on past experience, that rate times used in this installation are 50 percent faster than for a pneumatic system. The faster rate times make it possible to hold the controlled variable within a closer tolerance to the set point. Optimum settings for proportional band and automatic reset action were found to be comparable to similar settings for a typical pneumatic system.

The few difficulties that have been experienced have been of a type common to instruments in general. For example, several chart drive motors have failed, but the "plug-in" feature of the instruments greatly simplifies this problem in that a spare recorder can be placed in service and the faulty instrument repaired more conveniently and quickly in the instrument shop. There are also several instances of zero drift in the flow transmitters' D/P cells, which fault is common to most D/P cells and is corrected by the usual "working in" technique.

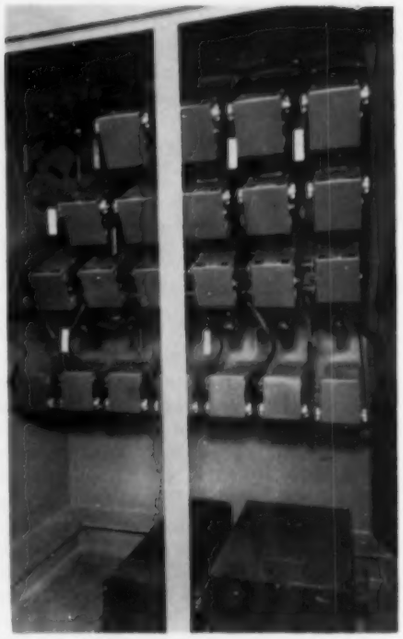
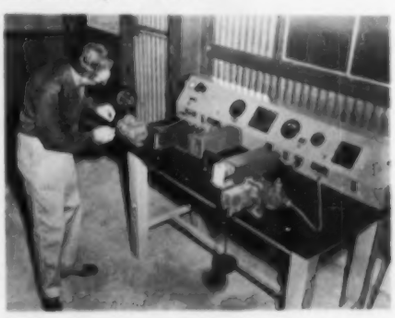


Figure 14: Interconnecting wiring behind the console.

Repeated failure of a flow transmitter metering the recycle gas on the discharge header of four compressors occurred. This transmitter was subjected to two unfavorable conditions: 1, considerable vibration which existed at its mounting and throughout the compressor house; and 2, the pulsating flow of the gas being measured. Providing a rubber cushion between the transmitter and its mounting bracket and in-

Figure 15: Test bench for maintenance and calibration of the units.



serting sections of flexible metal hose in both metering lines relieved the vibration condition. However, failures continued, and the problem was found to be more pulsation than vibration. The use of pulsation dampeners and a heavier assembly for the transmitter supplied by the instrument manufacturer solved the problem.

Operating Advantages: Speed of response of the instruments is definitely faster as compared to similarly installed pneumatic types. However, because of the limitations of pneumatic control valves, it has not been possible to take full advantage of this feature. There is considerable concentration of engineering effort underway to remove this obstacle, and undoubtedly more suitable control valves will be available soon.

The accuracy of the electronic measuring recording system is one half of one per cent. Unstable calibration has always been a problem with older types of instruments. However, the inherent stability of electronic instruments makes it possible to maintain accurate calibration for indefinite periods of time. Another operational advantage of this type of equipment is the fact that the recorder pen is completely dissociated from the controlling action. Thus, accidental deflection of the pen during inking operations, etc., does not affect control action. A very significant accomplishment is the fact that the entire Catformer is being operated by two men per shift. The electronic instrument system is not primarily responsible for this. However, it is certain that the ease and dependability of operation of the controls, together with the fact that the control arrangement makes all controls and instruments readily accessible and visible to a single operator, has been a factor. Of course, console construction is possible as a result of miniaturization, which is not exclusive to electronic instruments, but electric wiring lends itself more readily to console construction than does pneumatic tubing. (See Figure 14).

Maintenance Training Program: It is intended that plant personnel handle the maintenance of this equipment, and no difficulty has been experienced in carrying out this plan. The maintenance of electronic equipment is not completely foreign to the average instrument department in that electronic equipment in the form of temperature recorders has been in wide use in the process control field for many years. In particular, this equipment employs time-proven electronic circuits and components. The number of tubes, the circuit arrangements, and the components are in fact less complicated than the familiar home radio. However, because of the scope of this project and the many details of a new system, a definite maintenance program was set up. The plan carried out was to have an Atlantic Refining Co. engineer visit the instrument manufacturer for one week to be given extensive instructions. The engineer then conducted a training program at Atreco in the operation and maintenance of the installation. Training was given to both operating and maintenance personnel.

To facilitate the instruction at the refinery and to simplify maintenance, a special test set-up was made. (See Figure 15). The set-up is built around a portable Swartwout test unit which supplies simulated transmitter and set point signals and which is so mounted in the panel as to be easily removed for field checks. The bench also incorporates an adjustable voltage supply, an adjustable and regulated air supply, a voltmeter reading supply voltage, and a milliameter for controller output current. A vacuum tube voltmeter is used to read check point voltage when the set-up is used for maintenance work. This set-up makes it possible to assemble a complete control loop for system calibration and to serve as a demonstrator for class instruction. It also provides convenient outlets for test and calibration of the individual units of the system. The cost of material for this set-up was approximately $250, which can easily be justified by the time saved over repeated make-shift test set-ups and the consistent and accurate calibrations which are possible.

The practice followed in maintaining this equipment is to repair field mounted units, such as transmitters and power relays, on the spot if possible. Console mounted instruments, being of the "plug-in" type, are returned to the instrument shop, where they can be maintained more efficiently. It is comparatively easy to isolate a system failure in a particular unit, i.e., recorder, controller, etc. If the faulty unit cannot be conveniently or quickly repaired on the site, it is replaced with a spare instrument. The faulty unit is then set up on the test bench, and through a system of check point voltages, the trouble may be isolated in a particular section or component. Once the trouble is located, the unit is repaired and recalibrated and then placed in stock as a spare. Consistent and stable calibration and the ability to accurately preset control functions permit random interchange of units of the system. In addition, the ability to preset control functions accurately makes it unnecessary to go through a cumbersome "in service" cut-try adjustment procedure when interchanging controllers.

No unusual maintenance problems have been experienced; however, the installation has not been in service long enough to clearly establish maintenance requirements. It will be recalled that one of the factors influencing the decision to make this installation was the fact that maintenance requirements would be reduced and simplified. So far, the indications are that this expectation may be realized. The ready interchangeability of equipment, the test and calibration bench, and the standardized procedures established already have demonstrated that normal maintenance can be accomplished with minimum disruption of the process.

There have been no tube failures to date. A program of tube replacements at regular intervals has not been established but will be considered when sufficient data on tube failures are accumulated. It is interesting to note that industrial long-life tubes are used for the controllers, while standard tubes are used for the recorders. Since a recorder can be removed for repairs or tube replacement without disturbing control action, the use of industrial tubes costing approximately five times as much as standard tubes appeared uneconomic.

A complete stock of all necessary component parts for all anticipated maintenance has been established. In addition, complete spare recorders, controllers, transmitters, power relays, etc., are stocked on the basis of one spare unit for every ten units in service with a minimum of one spare unit of each type. Based on operations to date, it appears that the number of spare units could be safely decreased.

Conclusion: The obvious questions to ask after venturing into a new field such as this are: (1) Have the objectives been accomplished? (2) From the experience gained, what changes will be made in future installations? The answer to the first question is a definite "yes." The start-up was made without delay due to instrument failures and subsequent operation has been continuous and dependable. There have been no troubles peculiar to electronic systems, and while it is too early to draw conclusions regarding maintenance, it is clear that the electronic instruments can be maintained easily and without disruption of plant operation. The plant is operating with two men per shift and improvement in control action has been realized. Savings in first cost have not materialized to the extent originally estimated, largely as a result of expenditures on an emergency power system that experience has shown were unnecessary. A valuable and reliable amount of experience in all phases of electronic instrumentation has been acquired which will be exploited in future installations.

Although this first installation has been more than satisfactory, some improvements will be made in future installations on the basis of the experience to date. For example: (1) Future similar installations will not include such an elaborate emergency power system. (2) The field transmitters will have indications near the control valve. (3) Electronic or hydraulic control valves, if suitable ones are available, will be used where speed of response is significant. (4) Further simplifications and economies in interconnecting wiring will be adopted. (5) The absence of winterizing problems in cold climates will be exploited. (6) Initial stocks of spare instruments and parts will be reduced.

In conclusion, this plant has shown that electronic process control is here to stay, and there seems little doubt that the future trend is going to be strongly in this direction.

AUTOMATION

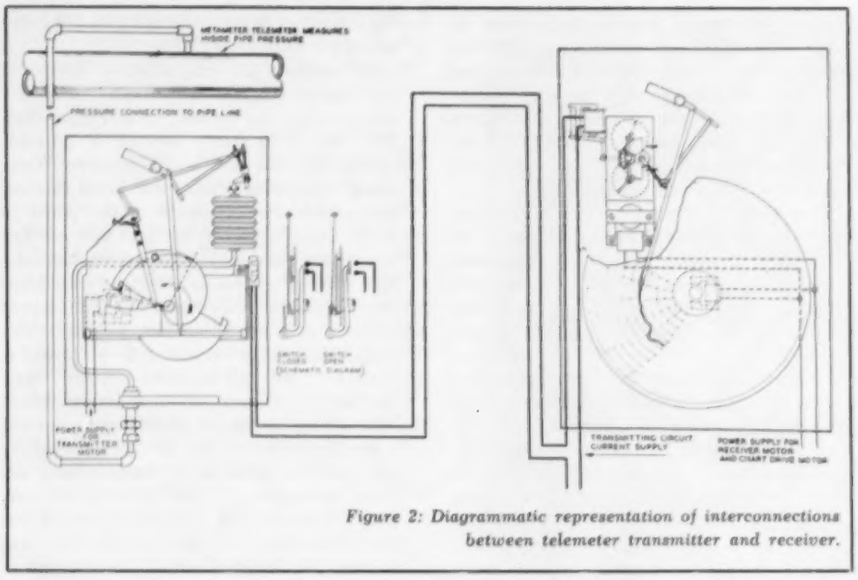

METAMETER TELEMETER MEASURES INSIDE PIPE PRESSURE
PRESSURE CONNECTION TO PIPE LINE
SWITCH CLOSES
SWITCH OPEN
(SCHEMATIC DIAGRAM)
POWER SUPPLY FOR TRANSMITTER MOTOR
TRANSMITTING CIRCUIT CURRENT SUPPLY
POWER SUPPLY FOR RECEIVER MOTOR AND CHART DRIVE MOTOR

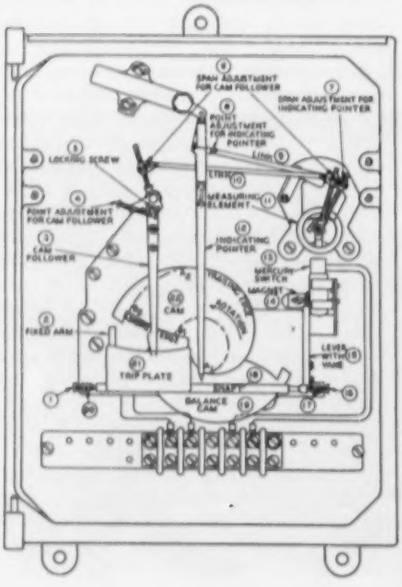
Figure 2: Diagrammatic representation of interconnections between telemeter transmitter and receiver.

TELEMETERING IN THE REFINERY

By W. E. Rufleth

W. E. Rufleth has been a member of the engineering staff of The Bristol Co. for the past 20 years. His specialty is the application and use of remote control, electrical measurement and telemetering instruments. He is a graduate in electrical engineering of the Rensselaer Polytechnic Institute.

Figure 1: Metameter telemeter transmitter for transmission of pressure measurements.



THE ROLE of telemetering in the refinery today is as yet somewhat undetermined. While it has proved to be a tool of great utility and importance in other process industries, the fact that information transmission is by *electrical* means has made it unacceptable in most refineries, where air is the accepted method of signal transmission. Naturally, the use of air to transmit information signals limits the distance from which these signals can be received, and thus also limits the centralization of the recorders and indicators receiving these information signals. In operations where the explosion hazard of electrical equipment is not critical, telemetering can be depended on to perform well and dependably. Recent installations prove that telemetering, like other electrical equipment, can be installed safely, if proper precautions regarding its use are observed. The receivers and transmitters can be made explosion proof as easily as can most other pieces of equipment, and then are as safe as an electric light bulb or klaxon.

Telemetering in its basic sense, of course, simply implies remote measurement, or the centralized reproduction of a measurement taken at a distant location. The measurement can be any variable—position, speed, pH, etc., but the measurements which refinery personnel are usually most interested in are temperature, flow and pressure. Occasionally, the position of a valve or gate, or the level of a catalyst bed or product in a blending tank is of importance. Also, in related operations, the levels in the storage tanks at a remote tank farm, or the flow of products through a pipe line either into or out of the refinery should be supervised.

As refineries expand and distances become greater, the use of telemetering may become mandatory as the lags in pneumatic transmission lines becomes excessive. If so, the principles involved in the telemetering equipment will be important to process men.

Some of the electrical methods of telemetering are affected by line impedance, and cannot be adapted to various modes of transmission, such as carrier currents and radio. An electrical impulse-duration system, such as the Metameter telemeter which we shall discuss, is not so affected.

The impulse-duration system of telemetering is analogous to the electromagnetic telegraph system, in that the signal transmitted is a function of time rather than an electrical quantity. The length of the electrical impulse (duration) is proportional to the measured variable (pressure, flow, temperature, etc.).

As in an electromagnetic telegraph system, a message is sent by means of a key; the telemeter transmitter sends the measurement signal. The telemeter transmitter samples the measured variable through a primary measuring device (bourdon spring, differential meter body, temperature element, etc.) and opens and closes a switch (key) accordingly. With a five-second impulse cycle system of transmission, the length of the signal transmitted will vary from one to four seconds (20 percent to 80 percent of the five-second cycle). For example, if we were required to telemeter a pressure range of 0 to 100 pounds per square inch, the length of the impulse would be one second at 0 pounds per square inch, 2.5 seconds at 50 pounds per square inch, and four seconds at 100 pounds per square inch.

The signal is repeated once every five seconds.

Figure 1 shows a Metameter telemeter transmitter for the transmission of pressure measurements with the motion from the measuring element (11) positioning cam follower (3). As the cam rotates, driven by a constant-speed motor, the tip of the cam follower slides across the cam surface (not along edge of cam) and drops off the trailing edge. It is again picked up by the cam's leading edge. As this happens, the trip plate (21) is moved in and out, opening and closing the mercury switch (13). If the cam follower is so located that it describes a path shown by B_1-A_1, an impulse one second long will be transmitted. If the cam follower's position is such as to describe a path B_2-A_2, an impulse four seconds long will be transmitted.

The receiving terminal of an electromagnetic telegraph system has a sounder or combination of relay and sounder; in the impulse-duration telemeter system, a relay or electromagnet converts the transmitted impulse to a mechanical motion for positioning a recording pen or indicating pointer.

The telemeter transmitter is connected to the telemeter receiver by an interconnecting system. This may consist of a completely metallic circuit (two wires) or one wire with a ground return. The interconnecting means may also be a telephone simplexed circuit, phantom circuit, composite circuit, carrier current channel, or radio, including even microwave transmission.

The telemeter circuit must now be energized. If the interconnecting system is metallic or one wire with ground return, the complete system is energized by a DC power source supplying approximately 50 milliamperes. Figure 2 shows such a circuit. In the case of a carrier or radio interconnecting link, the telemetering equipment is exactly the same as for use on a wired circuit. The telemeter transmitter "keys" the carrier or radio transmitter, and the output stage of the carrier or radio receiver "keys" the telemeter receiver.

So much for the basics of the time-impulse system of telemetering. Some of its specific applications will be of interest at this point.

As we have stated previously, the primary measurements of interest in refinery work are temperature, pressure and flow. Temperatures are usually sensed either by thermocouples or resistance thermometer bulbs, either of which generate signals which are amenable to telemetering as outlined above. Flow and pressure pick-ups or transducers are also very adaptable to telemeter transmission. A recent installation of telemetering equipment at a remote crude oil pumping station brought measurements of all three variables into the refinery for observation. The pumping station was located on the desert in California, operating under minimum personnel conditions with almost fully automatic equipment. In order to keep the engineer at the main pumping station (which supplied the refinery) informed of conditions at the remote station, one telemeter transmitter was installed for transmitting the temperature of the heated crude, another for pressure, and a third to measure the volume being supplied. These telemetered measurements were recorded at the main pumping station, and allowed the engineer there to keep his eye on two stations at once. Since this remote station is operated only part of the time, the flow of oil being insufficient to maintain constant pumping, this arrangement provides the most efficient method of operations, and fits in well with other work schedules.

This type of measurement and transmission finds many applications within the refinery itself, if proper electrical precautions are taken. Flows from one unit into another can be supervised and controlled, and the distance separating the units from each other becomes unimportant.

Another recent example of the way in which telemetering can be used in refinery operations is illustrated by the case of interface detection and product segregation in the pipe line from the refinery to the storage area. A pipe line company in the Midwest has the task of transporting oil products from four refineries to five terminal storage facilties through common pipe line facilities. In order to keep the products separate, and to direct them to their proper terminals and tanks, the pipe line dispatcher uses a complicated remote-manual control set-up with a graphic panel, including lights, valve controls, indications of operations, and also, recording telemeter receivers which tell him where the interface is, and when it arrives at the switching junction. When it does, he is then in a position to switch the valves at the junction, and direct the product into its proper terminal facility.

The interface telemeter operates on a dielectric principle. A radio generator of low power and fixed frequency applies a voltage across a specially designed cell through which the products flow (Nelson Electronic Products Indicator). The associated balanced electronic detecting circuit (Bristol Dynamaster Potentiometer) permits a small unbalance voltage to be developed which is related to the dielectric factor of the product in the pipe line. (These indications bear a close relationship to the API gravity of the products, thus identifying them in a relative manner.) The unbalance voltage is converted by the potentiometer-telemeter transmitter into an electrical signal, which is sent by the transmitter over a telephone circuit to a corresponding Dynamaster Metameter receiver at the dispatch office, where the dielectric constant is recorded. The receiver is equipped with alarm contacts; as the dispatcher operates, he sets the control pointer on the value of the product in the line. When a different product comes along, the value changes, causing the pointer to move and trip the alarm contacts. In this way, he knows that it is time to switch the flow into another channel or terminal.

This type of telemetering could very well be used in end-product analysis in the refinery, wherever differences in dielectric constants are sufficient to detect a change in processing conditions.

The techniques of telemetering are proving so valuable in other process industries that their use in refinery operations should be investigated thoroughly. Without any doubt, many areas of operation exist which could make use of telemetering's advantages and features to further the centralization of supervision and control already so well established in the industry.

AUTOMATION

The function of automatic logging in process control

AT ITS NEW 20,000-barrel refinery now under construction near Montreal, Canadian Petrofina will center all control for nine processing units in a single control room. This control center will house 126 feet of panelboard containing hundreds of conventional indicating and recording instruments which will report system performance at 480 points throughout the highly integrated refinery.

Occupying a section of the room only eight feet in width will be an automatic logger which will make a typewritten record of all of the 480 selected process variables in digital form. In addition, the $50,000 logger will prepare a punched record to facilitate subsequent analysis by Petrofina's accounting and engineering departments or to prepare summary reports for management on modern punch card or tape machines.

Operators of the plant will be relieved of the time-consuming drudgery of jotting down process condition data at the Petrofina plant and analysis for future refinery programming will be expedited. Accuracy of the typed and punched record will be far greater than is possible when instrument indications are visually noted and readings manually written.

The logger will aid Petrofina operators in keeping all units functioning as planned by making special reports on all significant deviations from normal. Ordinarily, the value of all variables will be typed at predetermined intervals such as hourly. Between normal logging intervals the logger will continue to scan all variables. Only selected or abnormal readings will be automatically reported during these periods. The operator will be free to demand a typed report of any process variable at any time to aid him in making necessary decisions.

The Petrofina logger is not the first of its kind to be built, but is the largest and most complex thus far undertaken. Where most such installations monitor a single unit, the Petrofina logger is intended to service nine refinery functions. The Montreal plant is to embrace the following manufacturing steps, all of which will be logged and controlled in the single control center: crude distillation, fractionation, catalytic cracking, reforming, vapor recovery, alkylation, polymerization, treating and blending.

There has been considerable discussion recently as to whether the refinery process can be made completely automatic. The answer usually is "no" because of the complexity of the oil manufacturing function. Raw feed is subject to considerable variation, even though carefully selected and segregated. Ambient temperatures are an important contributor to process variables despite maximum economic application of insulation. Process disturbances due to other causes may have important results in processes where the desired end result is based on so many interdependent variables.

For the present, at least, it seems necessary to place discretionary power in the hands of competent operators and to supply them with adequate information on which to base their decisions. The panelboard, with its small reporting devices placed on a simplified flow chart, is one such system. The operator also is aided by the console equipped with means of dialing any selected instrument and obtaining an instant report on pressure, temperature, liquid level or other variables. He is warned of process upsets by visual or audible alarm devices.

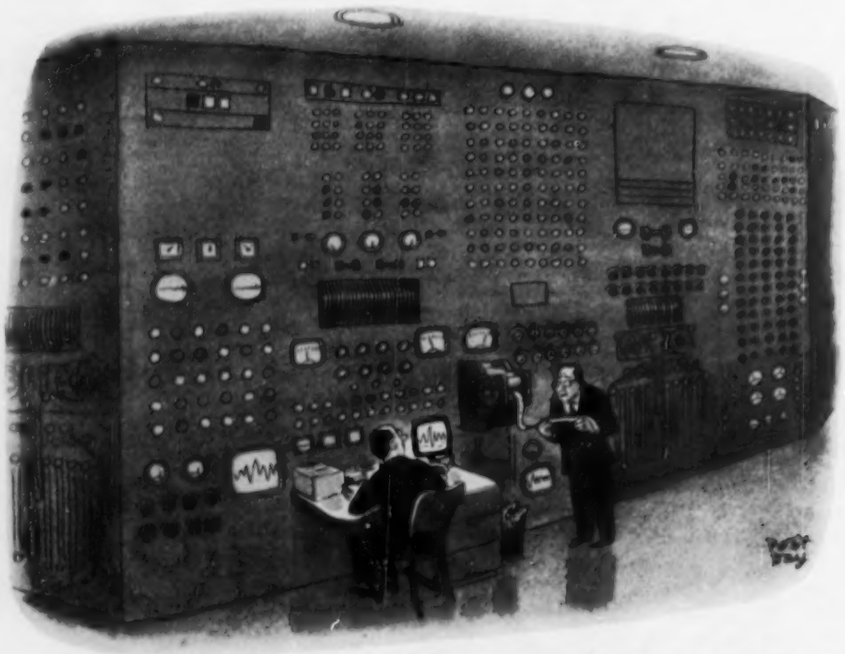
With so many factors affecting a modern refinery unit, the task of manually recording variables on log sheets becomes an onerous task. Errors are likely to occur which may seriously affect engineer appraisal of efficiency. Such errors become particularly important in emergency periods when everyone is busy.

When a logger is incorporated into the control system to gather and record accurately all pertinent factors, it is far easier to prepare heat and material balances and calculate yields. Data punched on tape or cards may be fed to computers employed for quality and efficiency control.

Printed data is arranged in columns of figures permitting ready reading by the operator who may wish to observe trends. Corrections may be applied as a result of these checks even though the process conditions may not have moved across maximum or minimum limits requiring emergency steps.

An essential feature of the automatic logger is means for connecting analog to digital data. Refinery instruments operate on electrical or mechanical analogs of the quantities actually measured. Numbers are represented by air pressures, voltages, resistances, shaft rotations, etc. Temperatures, pressures, liquid level or flow may be transformed into a shaft position by a self-balancing potentiometer and automatically

(*Continued on page* 160)



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"Something's wrong! It says my exact weight is one hundred and sixty-seven pounds and that I'm forceful in business matters, yet considerate of the feelings of others."

AUTOMATION

Left: M. L. Deutsch, mathematical physicist, joined Socony Mobil laboratories in 1949. He has been engaged in digital computer applications for three and one half years. Below: J. S. Hicks, chemical engineer, joined Socony Mobil in 1942 and has been concerned with digital computer applications for one and one half years.

SIMULATION OF A REFINERY BY A DIGITAL COMPUTER

By M. L. Deutsch and J. S. Hicks*

LIKE MANY another industry, the petroleum industry is more and more often faced with the problem of keeping its manufacturing operations currently appropriate in a continuously changing situation. With many refineries tending to process an ever-increasing variety of crudes into an ever-increasing variety of products, this problem has reached major proportions. The attempt to cope with these complex factors by taking advantage of the relatively recent development of electronic digital computers forms the major theme of this article.

It is probably not debatable that the question which an oil company's management is most anxious to have answered is: "How should my company be operated to make the most profit?" Obviously, the complete answer will probably always be inaccessible. But the answers to modest questions may not be. These more limited goals appear to be within the scope of modern mathematical techniques combined with electronic computation.

An example of this sort of feasible question, on the level of a single refinery, might be: "How should the refinery be operated to make those products which will yield maximum profits but meet commitments and other obligations?" This question could assume a given crude schedule or it could require the correct selection of crudes as well.

A second, even more restricted question, is: "If certain crudes, operating conditions, commitments, and product qualities are specified, how much of each product will the refinery make?" Refinery engineers will recognize that the answer to this question differs very little from the familiar refinery balance. Yet when advantage is taken of the great speed and automatic features of electronic digital computers, the refinery balance takes on a new quality. First of all, it provides an elementary optimization procedure, since many sets of operating conditions may be examined in the time usually taken to examine a single case. The best case examined is a sort of optimum. Secondly, it provides what may be described as a model of a refinery. Certain recently developed mathematical techniques give promise that this model may be subjected to a true optimization procedure. The following paragraphs deal with Socony Mobil's application of its new computer to finding the answer to the second question posed above, that is, how the refinery balance was programmed for a modern, electronic digital computer.

Socony Mobil Laboratories installed last year an ElectroData Corporation computer at their Research and Development Department in Paulsboro, New Jersey. Technically, the ElectroData machine is a general-purpose, magnetic drum, single address, digital computer of intermediate speed and capacity. The magnetic drum memory can hold 4,080 ten-digit numbers with signs. For ease of reference, following convention in these matters, Socony Mobil's computer has been nicknamed Mobilac.

Now, to program a refinery balance for Mobilac, or any other computer for that matter, the programmer requires of the refiner a set of principles for determining the path through the refinery of every barrel of every stock, and for determining the yields from each operation for each stock processed. In particular, for each process unit or operation in the refinery he must have a "principle of loading," i.e. a set of directions to designate which stocks are to be processed by the unit and how much of each. Since a computer is essentially a mathematical machine, it was necessary to simulate in appropriate mathematical form such processes and operations as catalytic cracking, reforming, alkylation, octane and vapor pressure blending and tetraethyl lead addition. These simulations are programmed for the computer and then are united by a master program into a mathematical model of the entire refinery. The master program itself simulates the piping between units and also contains the logical mechanism for making decisions when alternatives arise.

An additional factor to bear in mind is

* *Contribution from Socony Mobil Laboratories (A division of Socony Mobil Oil Co., Inc.), Research and Development Department, Paulsboro, N. J.*

AUTOMATION

Electronic engineer Lloyd L. Gainey checks the new electronic computer of Socony Mobil Oil Co., Inc., on an oscilloscope. Mr. Gainey helped install the mechanical brain, built by his company, ElectroData Corp., Pasadena, Calif., at the Paulsboro (N.J.) research and development laboratories of Socony.

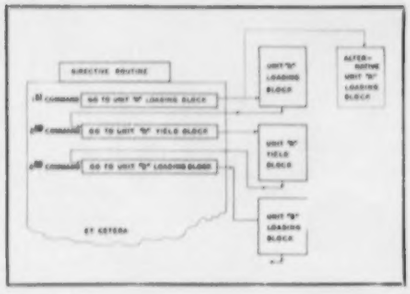
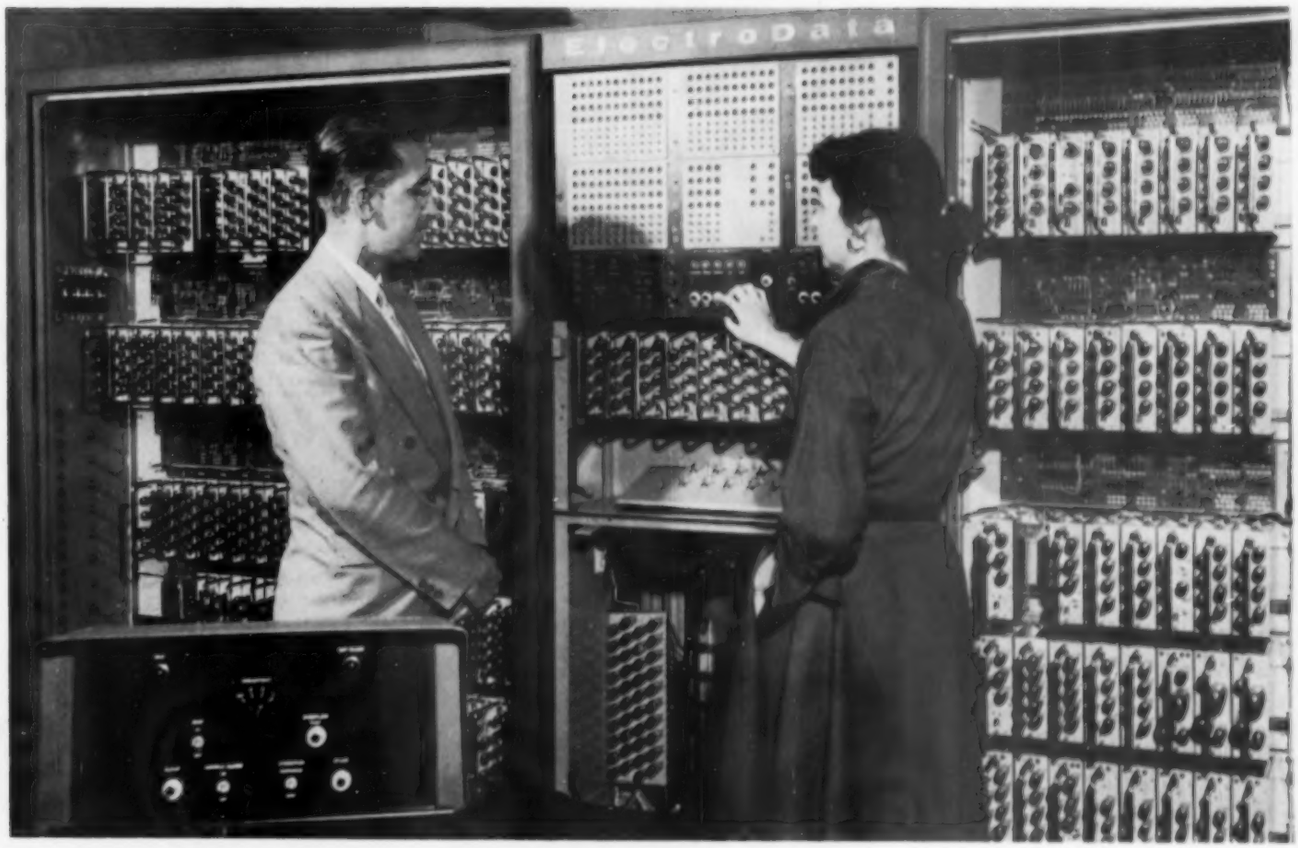


Figure 1.

that a refinery operating plan is far from static. A unit may be shut down for repairs or because of obsolescence, a new process may be introduced, crude supply sources may change, or various other changes may be made. Consequently, the computer program must be flexible. This has been achieved by programming in blocks or subroutines. For example, a catalytic cracking unit must be loaded to capacity from the available charge stocks. In loading a unit to capacity from the available charge stocks a group or "block" of computer commands incorporating the principle of loading for that unit decides which stocks and how much of each shall be charged to the unit and removes the amount charged from the list of stocks available to other units. Another block of commands calculates the yields of products from the unit on the basis of a correlation of yields with operating conditions. This correlation may range in complexity from a simple specification of fixed percent yields to a complete temperature-residence time-catalyst activity-stock type-recycle ratio correlation of the reaction kinetics. The advantage of the block system is that if, for example, it is decided to change the principle of loading, only the loading need be changed—the yield calculation block will remain as is, because it is general enough to obtain yields for all possible combinations of charge stock which might be fed to the unit. If there is more than one unit of the same type, a single yield block can be used to calculate the products leaving both units.

All the blocks which the program comprises are connected together with another block of commands called a directive routine. The directive routine comprises a series of commands which tell the computer which of the other blocks of commands to use and in what order, block by block. Perhaps an illustration will make this a little clearer.

Figure 1 shows what might be accomplished by the first three commands in the directive routine. The first command is: "Go to Unit "A" Loading Block." Upon reading this command, the computer would be directed to go to the first command of the Unit "A" loading block routine and to start executing the commands. The final



Miss Ann Tierney, laboratory technician, and T. W. Nelson, director of the Paulsboro research and development laboratories, test the new electronic computer installed by Socony Mobil Oil Co.

command of the loading block, reached after all the stocks to be charged to Unit "A" have been chosen and the amounts charged removed from inventory, is: "Return to the Directive Routine." The second command in the directive routine is: "Go to Unit "A" yield block." Again the computer is directed to the proper commands, the yields of all products are calculated and stored in specified memory cells and, finally, control is returned to the directive routine. In this fashion the computer proceeds through the entire refinery, breaking up the crude oil into boiling range fractions, converting various fractions into various products and summarizing the products available for sale.

If it is desired to load Unit "A" in a different way, merely changing the first command of the directive routine will direct the computer to an alternative block of commands. If the desired change was not anticipated during the programming, then a new block must be programmed and inserted in the model. But this new block is the only change—the remainder of the routine is not changed. So, using this block or sub-routine system, changes can be made to suit new situations fairly easily and hence the refiners can be provided with real service.

The refinery calculation programmed involves some 6,000 commands, many of which are in blocks which may be executed a large number of times. The fact that some 6,000 commands are involved means that the entire program exceeds the 4,080 command memory capacity of Mobilac by about 2,000 commands, so that part of the program must be loaded and unloaded for each case of any given problem. A total of nine minutes is required for one refinery balance. This is the elapsed time between start of data input and end of data output. Actually, about six of the nine minutes are spent in loading the program, leaving only about three minutes actual calculating time.

The time required per problem can be reduced considerably by use of a faster loading device. In fact, the use of auxiliary magnetic tape storage would reduce the program loading time to about 15 seconds, so allowing another 20 seconds to load the punch cards containing the input data required for each problem, the total time per problem would be about 3½ minutes.

To sum up, a mathematical model of an existing oil refinery has been programmed for Mobilac. The model incorporates simulations of all processes in the refinery. It can be used to get an answer to the question: "What finished products will we get if we charge so many barrels of so many crudes under the following operating conditions?" The answer will be the same as that obtained from a hand calculation made by the technical department of a refinery, but the computer will furnish the answer in 1/400th of the time. The computer's answer will, of course, be subject to whatever errors are inherent in the correlations and other computation information furnished by the refinery.

The program is reasonably easy to modify so that refinery equipment changes and changes in the interconnections between units can be kept up to date. The program has been used by the technical department of Socony Mobil's Paulsboro refinery for economic studies and should shortly pass into the realm of the routine.

AUTOMATION

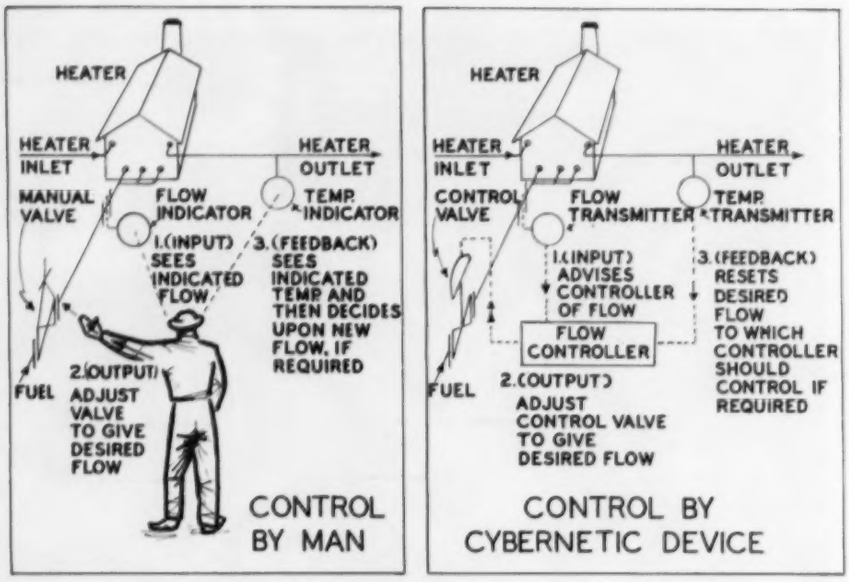


Figure 1: Simplified comparison of human versus cybernetic control of a heater.

Design factors affecting

CYBERNETICS IN THE

By John L. Cushnie

John L. Cushnie, project engineer for Catalytic Construction Co., has been engaged for the past 15 years in the chemical, petrochemical and petroleum fields involving process design, pilot plant operations and project engineering. He has been with Catalytic for four years. Previously he worked for Caltex, du Pont and the Barrett Division of Allied Chemical and Dye.

THE PETROLEUM INDUSTRY illustrates the use of cybernetic devices or automatic control equipment in a highly developed stage. This accomplishment has been possible partly because petroleum is in the group of process industries which are particularly adaptable to control by instrumentation. Another favorable influence is that petroleum refineries quite frequently add new plants or extensively revamp existing ones and are, therefore, able to make use of the latest control equipment.

Cybernetics is the science of control and communication theory. It is derived from the Greek word meaning "pilot" or "steersman." The dictionary definition of "cybernetics" is "the comparative study of the control system formed by the nervous system and brain and mechanical-electrical communication systems." A device which may be called cybernetic is one whose behavior approaches human behavior (see Fig. 1): a message from the outside (input) is received; a message is sent to the outside (output) and a second message is received from the outside (feedback) to indicate the effectiveness of the message it has sent.

Basically, technological developments can be classified in two general groups: mechanization and automatism. Mechanization, a word of long standing and popularly understood, means "the process of making mechanical (made or done by machinery)." Automatism means the "process of making self-controlling." Each of these two groups contain examples varying greatly in their complexity. Mechanization may include something as simple as a lever or as complicated as an adding machine. Similarly, automatism may range from an automatic fire sprinkler to an anti-aircraft fire-control system. These cited cases are intended to indicate only the degree of complexity and not the extremes.

The self-controlling features of some equipment found in the automatism classification are of minor importance when compared with its major function. For instance, an automatic saw for cutting steel bars is primarily a sawing tool, and is self-controlling only to the extent that its action stops when the bar has been sawed through. The only evidence of a message being sent is from the saw, when it has been lowered to a pre-determined elevation, to its source of power. Only this one message can be sent and then in only one direction. Such a machine's function so slightly approaches human behavior that it is worthy of being called automatic only, and not cybernetic.

Other devices have been developed with the sole purpose of controlling equipment. An example is the firing controls for a heater (see Fig. 1) where the flow of fuel is regulated by a flow controller which in turn is reset (or adjusted) by a temperature controller at the outlet of the heater. In this case the controller receives a message indicating the rate at which fuel is being fed. If this rate varies from the desired rate, the controller sends a message to the fuel valve which then adjusts to bring the flow back to the desired rate. A second message is at the same time being sent to the controller from the outlet of the heater denoting its temperature. On receiving this second message, the controller resets the desired fuel rate if the temperature is different from that desired. The operation of this controller is comparable to the behavior of a man firing a heater (both receive the same messages and send the same messages to the fuel valve) and is definitely an example of cybernetics. This type of control in which two or more variables are united in an integrated system is called "cascade control."

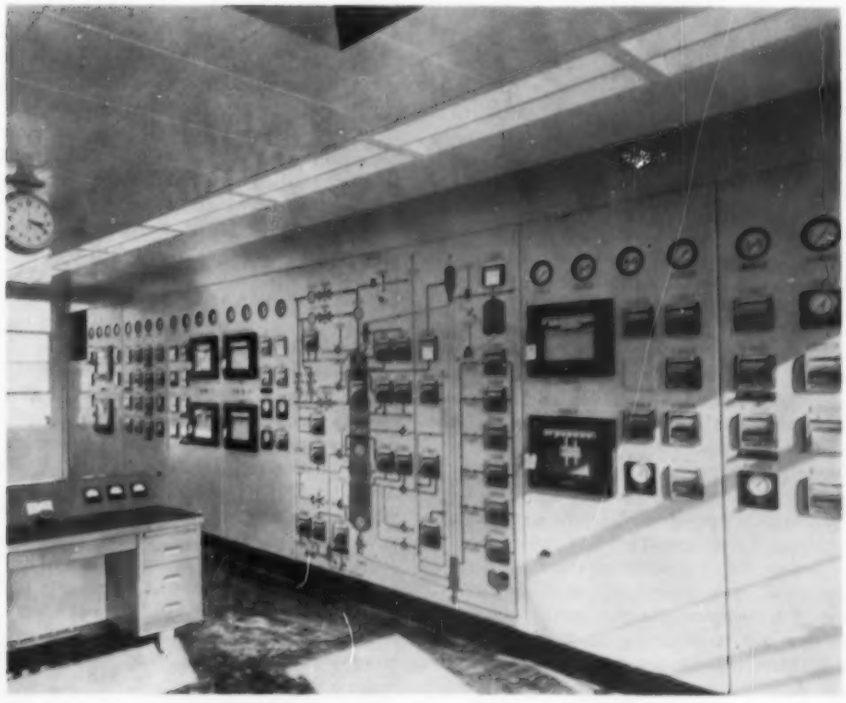
The word "automation" is being used quite popularly to indicate the trend in the use of automatic and cybernetic equipment. J. J. Brown, of Aluminum Fiduciaries Ltd., has recently[1] objected strenuously to the "ill-considered coinage" of "automation" and shown clearly that existing words already adequately define "all known forms of automatic control of processes and machines."

It is probable that "automation" owes its value to being a catch phrase as, in the past, have such expressions as "mechanical," "automatic," "assembly line," "electrical" and "electronic." Their usage has been somewhat hypnotic in attracting attention to new equipment and at the same time giving the impression that it is economically feasible. Naturally, a new word is occasionally necessary to keep the "spell" from wearing off. Engineering personnel have undoubtedly found these phrases useful in selling the use of devices which, on their own merits, are justifiable. It should be kept in mind that changing the names from time to time has not varied the everlasting aim of "accomplishment with least effort."

[1] *Control Engineering*, March, 1955, McGraw-Hill.

PETROLEUM INDUSTRY

Figure 2: Control house at the Sarnia, Ont., refinery of Sun Oil Co. In this one control room are located three-quarters of the 200 process variables in the entire plant.



The principal considerations in selecting the instrumentation for a petroleum refinery unit are the process itself, product quality, economy of operation and safety. The first three of these factors are studied simultaneously; any device which is favorable to one of these considerations will similarly be advantageous to the others.

A petroleum process has certain variables, such as temperature, pressure, rates, which have to be maintained constant for successful operation. Some of these variables can be controlled directly and some may depend upon other variables which then require controlling. The aforementioned heater firing control is an example of this latter case; the outlet from the heater is maintained constant by controlling the fuel to the heater.

The product quality, as well as the yield, depends upon uniform operation of the process. The instruments selected for automatic control of course maintain constant operating conditions and therefore insure the optimum quality and yield of product. Similarly, the most economic operation is at the same time attained. The elimination of operating variations not only is favorable to the product, but also brings about savings in steam, fuel, water, etc. used in the process.

Finally, the process is studied to determine what might happen in case unexpected conditions would arise. If any of these conditions are unsafe for the equipment, it is necessary that automatic interlocking systems be installed to insure that the cause of such a difficulty can be stopped. The use of relief valves in case of excessive pressure is a simple variation of this consideration.

A particular refinery which is quite indicative of the use of cybernetic devices in the petroleum industry is the Sun Oil Company Ltd. refinery in Sarnia, Ontario (see WORLD PETROLEUM, May 1954). One centrally located control house is used for the operation of all the process units: butane-butylene flash, crude, atmospheric flash, Houdriflow catalytic cracking, synthetic crude, Houdriformer, gas plant and gasoline and kerosine treating. For the proper operation of these units some 200 process variables (such as temperatures, pressures, flow rates and levels) must be controlled. The controllers for approximately three-quarters of these variables, many of which may occasionally require resetting, are located in the control house where they are readily accessible to the operators. These

controllers are accompanied by recorders, and for the more critical conditions, alarms also. The remaining variables (largely pressures and levels) are ones always controlled to unchanging values, and their controllers are located locally at the equipment or in the piping. For most of the local controllers these are recorders or alarms, or both, in the control house to keep the operators informed.

A large number of the instruments in this refinery are installed in cascade control systems, similar to the heater firing controls earlier mentioned. Each of these integrated systems provides better control of the variables than could be expected by separate control of each variable with the correlation between the two being accomplished by operating personnel. In these cases the possibility of human errors and delays is eliminated.

Also there are a number of interlocking systems which function only in cases of dangerous conditions. For instance, if the temperature of a heater oil outlet exceeds a certain safe value, the normal fuel control system will be over-ruled and the flow of fuel stopped. If this temperature were permitted to rise, the heater would soon be operating in a condition unsafe for the equipment and consequently to personnel. In other cases these interlocks are used essentially for protection of equipment. A high level switch in an accumulator, providing gas to a gas compressor, is used to shut down the compressor driver and thereby insure that no liquid feed is introduced. Liquid in a gas compressor would at least greatly overload the equipment if not bring about its breakdown. After one of these interlocks has halted a variable or piece of equipment, it is necessary for an operator to reset the device after locating and correcting the cause of the trouble. Otherwise the difficulty would only recur.

The instruments for the various process units are arranged in the control house so that they are most convenient for the operating personnel. A graphic panel is used for the Houdriflow catalytic cracking unit instruments and provides the operators with a simplified replica of the process. The instruments for the remaining process units are grouped on individual panels. Therefore, the behavior of all the important variables of a unit can be determined by viewing a single area on the control board. The temperature of any thermocouple in the refinery can be obtained by simply dialing its number at a console located in the middle of the control house.

Automatic equipment is also used in the blending of finished products. To obtain the desired Reid vapor pressure of the gasoline for sales, a certain percentage of butane is added. This is accomplished by controlling the addition of butane to the gasoline being pumped for blending so that the ratio of the two remains constant. Since the butane and gasoline are blended in the correct proportion in a transfer line, the need of time- and power-consuming recirculation in a tank to insure uniform mixing is eliminated. Similarly, automatic blending equipment is used for the addition of tetraethyl lead to the gasoline with the same resulting advantages.

The total number of men required for the operation of Sun's Sarnia refinery is ten per shift. Of these, one is a supervisor, six care for the operation of the process units, one is a laboratory man and the remaining two work on the auxiliaries such as the oil-water separators and the tank farm.

Refineries with lube oil and grease facilities also require other types of automatic equipment. Automatic equipment is used in filling drums and cans with exact quantities of products. Some of these devices are arranged to measure exact weights of materials, while others measure exact volumes with compensations for differences in temperature. As with other industries, many of the smaller containers are also automatically packaged in cartons ready for shipment.

The purpose of cybernetic devices in the petroleum industry is to provide better operation of the processes. Included with "better operation" are higher yields, better quality products and safer conditions. In some cases the operation without such controls would be almost, if not completely, infeasible. A well-known example is in the Houdry catalytic butane dehydrogenation units for manufacture of butadiene or butylenes with fixed-bed catalyst. This process calls for batch equipment to be operated in a continuous fashion. The dehydrogenation reactors may be arranged in different groupings, but for purposes of illustration, groups of three are considered. In each group, while one reactor is being used for the dehydrogenation operation, the second one is having its regeneration completed and being prepared for use as a reactor. During this same period of time the third reactor is being prepared for and starting its regeneration. The cycle for a subsequent group of three is identical, but starts at a later time. Some 50 to 100 valves, depending upon the number of reactors, require opening and closing at specific times for operation during one complete cycle.

With the aid of remote push buttons, it would be possible for this large number of valves to be operated by several men during a cycle period of approximately 20 minutes, but their work would be very monotonous and subject to human error. Therefore, it is almost necessary that such an operation be operated by a cycle timer which at exactly the correct time automatically controls each of the valves. An extensive interlock system accompanies this cycle timer to insure that a dangerous condition cannot result from failure of a valve to function. For instance, the regeneration of the catalyst in a reactor requires the use of air, and therefore it is imperative that the air valve remain closed until the hydrocarbon vapors remaining after the dehydrogenation have been purged from the reactor. It is doubtful whether this process would have been accepted without the unfailing assurance given by the interlock system that such dangerous conditions could not occur. Dependence upon the human element would be too risky.

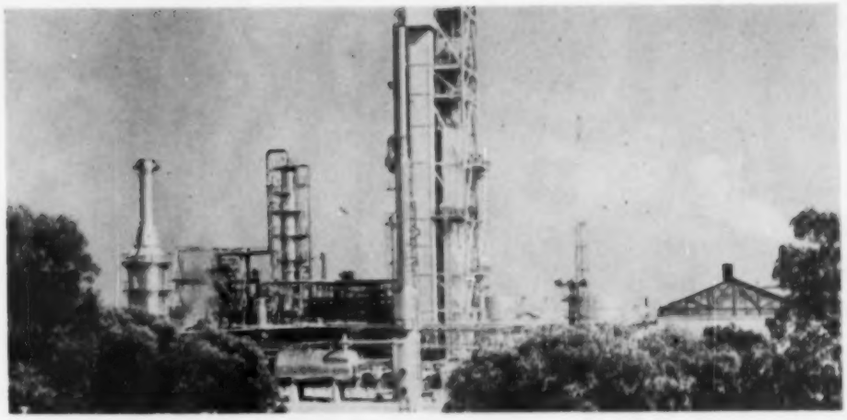
The mere mention of a technological advance has always inherently brought about two contrasting opinions—one of hope to management, the other of concern to labor. Management hopes for an improvement in the efficiency of its operations; labor is concerned about the possibility of unemployment. Over any appreciable period of time it is difficult to imagine any occurrence that would treat the two groups differently. Past experience has clearly shown that when the management group enjoys a favorable economic condition, the labor group shares this same condition. An unfavorable condition is also shared.

It is reasonable to believe that the pattern set in the mechanization of our economy is continuing for cybernetic advancements. In both cases, the number of people required for a specific operation or group of operations is reduced. At the same time, new jobs requiring greater skill are created. The introduction of machines to take the place of manual labor brings about the requirement for people to design, build and maintain them. These new jobs demand new skills and more extensive training, thus better utilizing the abilities of the men. The opportunities for employment are changed from one field to another, but are not reduced. This has been evidenced for a long time by reductions in the number of farmers and increases in the number of industrial workers with simultaneous increases in food production. As the efficiency of an economy is improved, the standard of living of its people improves.

One significant aspect of industrial advancement which may not normally be given much consideration is that it gives people a mental satisfaction by making better use of their abilities. Certainly it is more satisfying to perform a function that cannot be accomplished by a machine than one that can be done better and faster by machine. Prof. Weiner of M.I.T. warns against the dangers of minimizing "the human element" in one of his books on cybernetics, *The Human Use of Human Beings.*[2] The title itself is indicative of the importance of the human being.

To attain a higher standard of living, an improvement in efficiency is necessary. This efficiency can be defined as the amount of productivity per person. Increased working hours should of course increase productivity, but this method would not approach "the human use of human beings" applied in providing men with equipment to accomplish this result in the same or possibly less time. As long as the aim of improving the standard of living remains, there is a certainty that the trend to automatic and cybernetic equipment will continue.

[2] *The Human Use of Human Beings;* 1950, Houghton Mifflin Co., Boston.



Refinery completed late in 1954 at Pettijean, Morocco.

New Coryton refinery of Vacuum Oil Co., Ltd., British affiliate of Socony Mobil Oil Co., Inc. Located on the Thames River estuary, the refinery has a crude running capacity of 20,000 b/d and manufactures a full line of lubricants. Photo courtesy Socony Mobil Oil Co., Inc.

Eleven refineries expand still capacity in

EASTERN HEMISPHERE

WITH THE erection of 11 new refineries and the expansion of others, refinery still capacity in the Eastern Hemisphere increased 705,094 barrels daily in the year ended July 1. Cracking capacity increased 143,000 b/d.

Crude still capacity in July was 6,176,087 b/d and cracking capacity 784,030 b/d. Increase in crude capacity was nearly 13 percent and in cracking capacity 22 percent in the 12-month period.

Capacity of Asian refineries increased 96 percent in the past 12 months as large new plants were completed in India, Australia and Iraq. Soviet Russian increases are not included in the figures quoted.

In Oceania the increase in capacity was 30 percent. The Philippines became a refining nation for the first time and a large new plant was completed in Australia. Indonesian capacity was enlarged.

European capacity was increased 25 percent within the past year exclusive of USSR. In Russia it has been estimated that capacity expanded in line with crude production and that current still capacity is about 1,350,000 b/d compared with 1,200,000 b/d at mid-1954. Romanian capacity is now estimated at 210,000 b/d, a substantial increase over last year.

The European refinery industry, at least three times the size it was before World War II, is entering a period when the need for rapid expansion is past. Only a normal expansion to meet growing demand, on the order of five to seven percent a year, is in the offing.

The capacity of European refineries was something over 2,250,000 b/d at the start of this year, according to estimates by the U.S. Department of the Interior. This figure includes Spain and a few other non-OEEC countries.

Against this, there is a demand on the order of 1,700,000 barrels daily, and recently the refinery output of products has been running at a rate of 1,920,000 barrels daily, the Department of Interior reports. This figure includes a bunkering use of just over 200,000 barrels daily. The rapid rate of rise in European consumption is shown in Table I on page 77.

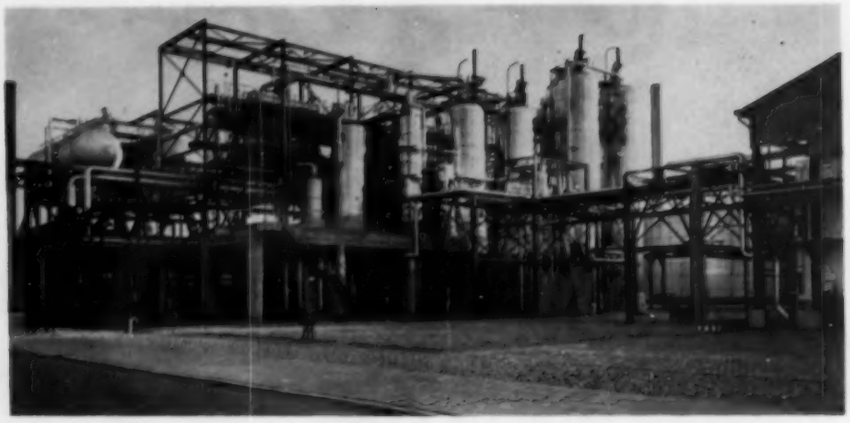
A rate of increase of five to seven percent a year in consumption is regarded by OEEC as "typical of a stable and expanding economy." A shift to gasoline is seen with refinery output this year estimated at 26 percent gasoline as against 23 percent three years ago. Kerosine, the basis of jet fuels, is 4.4 percent as against 3.4 percent three years ago. A drop in the fuel oil ratio to 38.5 percent of output is seen this year as against 45.5 percent three years ago. More lubricants, too, are coming out.

The pattern of consumption in Europe as well as the price levels are affected markedly by the tax structure. Gasoline, for instance, pays taxes that are so high that a change in the refinery price would make only an insignificant change in the price the consumer pays. Therefore, the industry can do little to step up gasoline consumption by lowering prices. As a matter of fact, there is a trend toward raising the price of distillate to put the industry on a sounder base.

As the OEEC summed up the story in the report, it said:

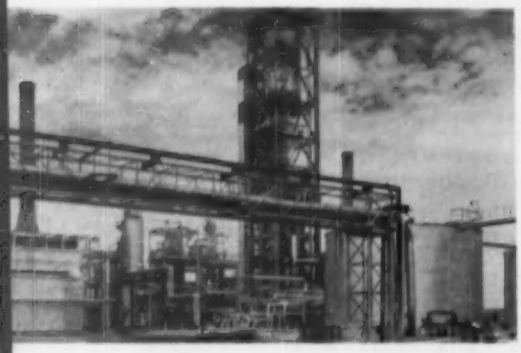
"The total consumption of oil in Europe, which has been increasing rapidly since the war, is expected to show a continuing increase, but at a slower rate. Similarly, the

A night view of the Kwinana refinery of Australasian Petroleum Refinery Ltd. (associate of British Petroleum Co. Ltd.).

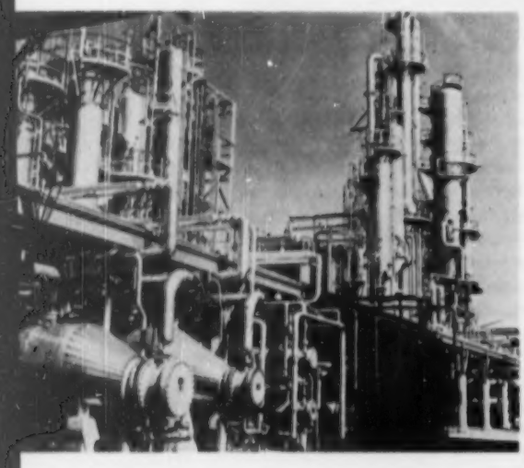


World's largest propane deasphalting and decarbonizing units installed at the Pernis refinery of Bataafsche Petroleum Maatschappij. A Shell photograph.

A view of the 286-foot Thermofor catalytic cracking unit at the Altona, Australia refinery of the Standard-Vacuum Oil Co. Other units to the left of the towering structure are the crude oil furnace, the TCC fractionator and the TCC gas plant installation.



The 500,000 ton per annum catalytic cracking plant with exchangers and fractionating towers at the Antwerp refinery of Societé Industrielle Belge des Pétroles (jointly owned by British Petroleum and Petrofina). A British Petroleum Co. photograph.



expansion of refining capacity which has also taken place very rapidly is expected to continue considerably more slowly for the next few years.

"The estimates made by the different countries indicate that during the period under review, refining capacity is likely on the whole to be used at least as fully as is normally the case in this industry.

"Europe achieved in 1953 a small net export of refined products. While imports will still take place in certain products, on balance Europe is expected to be in the position of a net exporter of refined products during the period up to the end of 1956."

A story of refinery progress and what lies ahead is due from the Organization for European Economic Cooperation this summer, but few expect it to differ markedly from the latest OEEC report which was made public at the start of this year.

A number of the tables from that report are condensed in Table III.

Completion of work previously undertaken brought large capacity changes to Belgium, Germany, Italy and the United Kingdom.

Outstanding refinery completions during the year were those of British Petroleum at Freemantle, Australia; Burmah-Shell Refineries Ltd. at Bombay; and Caltex in the Philippines.

The B. P. Kwinana refinery on the outskirts of Freemantle in southwest Australia has a crude capacity of 60,000 b/d. The plant was described in detail in the February 1955 issue of WORLD PETROLEUM. Since that time a hydrofiner has been commissioned with the result that all units are now in operation.

This hydrofiner for the desulfurization of gas oil was developed in the Sunbury-on-Thames research station of B.P. and must not be confused with the Autofiner developed at the same station which is B.P.'s patented process and already in operation at Llandarcy.

Hydrofining is used where there is an external supply of hydrogen, such as arises from a Platforming unit, but Autofining does not require this external supply.

The first Universal Oil Products Co. licensed Unifining unit to go into operation outside the United States started up recently at the refinery of Bitumen & Oil Refineries Ltd., Matraville, New South Wales. The former 1,500 b/d Platforming unit built in 1952 is being enlarged to a capacity of 2,300 b/d.

Provisions were made in the design of the Unifining unit to expand it so that it can be operated on a blocked-out basis to handle crude light aromatic oils for subsequent recovery of aromatics as nitration grade benzene, toluene and xylenes as an alternate operation to desulfurize diesel fuel.

Standard Vacuum Refining Co. Ltd., has completed expansion of the crude capacity of its Altona refinery from 2,000 b/d to 25,000 b/d. A 10,000 b/d Thermofor cat cracker was installed. Current work involves the construction of a 1,600 b/d alkylation unit which will be completed in 1956.

Elsewhere in this issue will be found an article describing in detail the new Burmah-Shell 40,000-barrel refinery at Bombay which recently began operations. This is the second plant to be built in India. A third also is planned.

The Caltex refinery at Batangas, Philippine Islands, was officially opened on December 11 last. This $30 million refinery has a crude capacity of 13,000 b/d and includes a fluid cat cracker and cat poly unit.

In Japan the Nippon Oil Co. is installing a 6,000 b/d topping unit which will be completed in November at its Kashiwasaki refinery. It is also building a 600 b/d Platformer and a 1,000 b/d furfural extraction unit. These units will be completed late next year. At the Wakayama refinery of Toa Nenryo Kogyo Co. a 10,000 b/d cat cracker is under construction.

In the Middle East the principal refinery

construction work during the past year has been for the Iraq Government. A 24,000 b/d refinery has been completed at Baghdad and a 1,200 b/d asphalt plant has been commissioned at Qaiyarah.

Arabian American Oil Co. is building a 12,500 b/d fluid hydroformer at Ras Tanura. The unit will be ready for operations next January.

Bahrain Petroleum Co. Ltd. is building a 23,000 b/d vacuum unit to provide charging stock for an 18,000 b/d fluid cat cracker. A 1,500 b/d cat poly unit also is being built. Completion target is 1957.

Kuwait Oil Co. Ltd. is building a 600 b/d asphalt plant at Mena al Ahmadi.

In Lebanon the Mediterranean Refining Co. completed a 6,250 b/d refinery at Sidon late in 1954. Capacity is now being increased to 9,000 b/d. This work will be completed by 1956.

Turkey plans construction of a 6,250 b/d plant at Batman to include a cat cracker.

The Egyptian Government is reported to be increasing the capacity of its Suez refinery to 26,000 b/d. A 20,000 b/d refinery is planned for construction at Cairo.

Detailed reports on operations in England and France are published elsewhere in this issue.

On the continent, the refinery at Antwerp, jointly owned by B.P. and Petrofina, is increasing its crude capacity by the installation of a second distillation unit which is now due for completion. A cat cracker is also being built which will come into operation about the same time as the new distillation unit. A cat poly unit was put into commission in December 1954.

At the Pernis, Holland refinery of the Bataafsche Petroleum Maatschappij a new cat cracker of 33,000 b/d capacity is under construction and due for completion in mid 1956. An Edeleanu plant of 9,400 b/d output is being built and is due to go into commission in the fall of this year.

Extensions have been made to the lube oil refinery which will bring the production up to 1,750 b/d. These extensions went into commission in the first quarter of this year.

One of the world's largest deasphalting and decarbonizing units, designed for a maximum oil charge rate of 12,000 b/d and a propane circulation rate of close to 100,000 b/d, was included in the Pernis refinery for the production of lubricating oil base stock and catalytic cracking unit feed stock. The Badger Process Division of Stone & Webster Engineering Corp. did the process design of the new deasphalting unit. Mechanical engineering and drafting were done in London by E. B. Badger & Sons Ltd., Stone & Webster's U.K. subsidiary.

An unusual feature of the new Pernis unit is the use, for the first time anywhere in deasphalting units, of multiple effect evaporation to remove the propane from the oil stream, resulting in high heat economy. The high propane-to-oil ratio used in this plant to effect maximum extraction of lubricating oil from the reduced crude and the high value of fuel in Holland makes heat economy particularly important. The raw stock fed into the Pernis unit is usually La Paz reduced crude.

At the Caltex refinery at Pernis a 7,000 b/d Platformer and a 4,000 b/d desulfurization unit are being built. Completion will be in 1957.

At the Harburg, Germany refinery of the Shell Group, a catalytic reformer of 2,300 b/d capacity is under construction and due for completion in mid-1956.

Esso A.G. at Hamburg-Harburg is increasing its crude capacity to 43,000 b/d and building a 7,000 b/d catalytic reformer. Both will be completed in 1956.

Ruhroel GmbH. at Bottrop is rebuilding its hydrogenation unit and constructing a 5,500 b/d cat cracker.

Contracts have been awarded for installation of a Houdriforming unit, including a Houdry guard case pretreating section, at the Gewerkschaft Erdoel-Raffinerie Emsland refinery in Lingen, Germany.

The Houdriformer will be of 3,000 b/d capacity. The Lummus Co. Ltd. of London will handle over-all engineering and construction of the plant based on process designs by Houdry Process Corp. The Emsland refinery now has in operation a 17,500 b/d Houdriflow catalytic cracking unit, processing a mixture of nearby German crudes.

A major future addition to European refinery capacity is to be built in Greece by the government. This is to be a 30,000 b/d plant equipped with thermal cracking and catalytic reforming. Completion will be in 1957.

Neste Corp. is building an 18,000 b/d refinery at Turku, Finland, the first refinery in that country. Recently, Finland has been buying most of its refined oils from USSR sources.

Construction has been active in Italy during the past year as earlier projects have come to fruition.

TABLE I

CONSUMPTION INSIDE THE OEEC COUNTRIES
(Excluding Bunkering)

Year	Barrels Daily
Prewar Average	522,000
1948	726,000
1949	820,000
1950	964,000
1951	1,114,000
1952	1,166,000
1953	1,298,000
1954	1,398,000
1955 Est.	1,476,000
1956 Est.	1,550,000

TABLE II

REFINERY OUTPUT OF WEST EUROPEAN COUNTRIES, 1955
(Compared with Distillation Capacity)

Country	Barrels Daily	Percent
Austria	—	—
Belgium	86,240	98.0
Luxembourg	—	—
Netherlands	190,252	84.5
Benelux	—	—
Denmark	520	100.0
France	448,320	81.5
Germany	181,700	74.0
Greece	—	—
Iceland	—	—
Ireland	—	—
Italy	260,400	60.0
Norway	1,264	100.0
Portugal	15,672	65.5
Sweden	33,000	82.5
Switzerland	3,720	93.0
Turkey	6,004	98.5
United Kingdom	534,200	93.0
TOTAL	1,761,280	80.0

TABLE III

THE REFINERY PICTURE IN OEEC COUNTRIES
(Barrels Daily)

Year	Distillation Capacity	Crude Thruput	Thruput as % of Capacity	Refinery Output
1952	1,642,000	—	—	1,364,000
1953	2,008,000	1,636,000	81%	1,522,000
1954	2,084,000	1,870,000	84%	1,684,000
1955 Est.	2,162,000	1,904,000	87%	1,761,280
1956 Est.	2,246,000	1,960,000	87%	—

A Platformer is being built at the Porto Marghera refinery, Venice, jointly owned by B.P. and Azienda Generale Italiani Petrole (AGIP), which will have a capacity of 2,000 b/d. Work on foundations has been completed and construction of the actual unit commenced in June.

A 3,550 b/d cat reformer and a 4,800 b/d splitter are being built by Garrone at its Genoa refinery.

Purfina Italiana is building a 1,000 b/d Platformer at Genoa and a 3,000 b/d vacuum distillation unit at Milan.

Socony-Vacuum is building a 2,000 b/d cat cracker at its Naples refinery.

SARPOM is building a group of units at Trecate, Novara. Included are a 2,800 b/d cat cracker, a 5,150 b/d vacuum unit and a 315 b/d cat poly unit.

STANIC is building an 8,900 b/d catalytic reformer at Leghorn and at Bari crude capacity is being increased 4,850 b/d. Both units will be completed late this year.

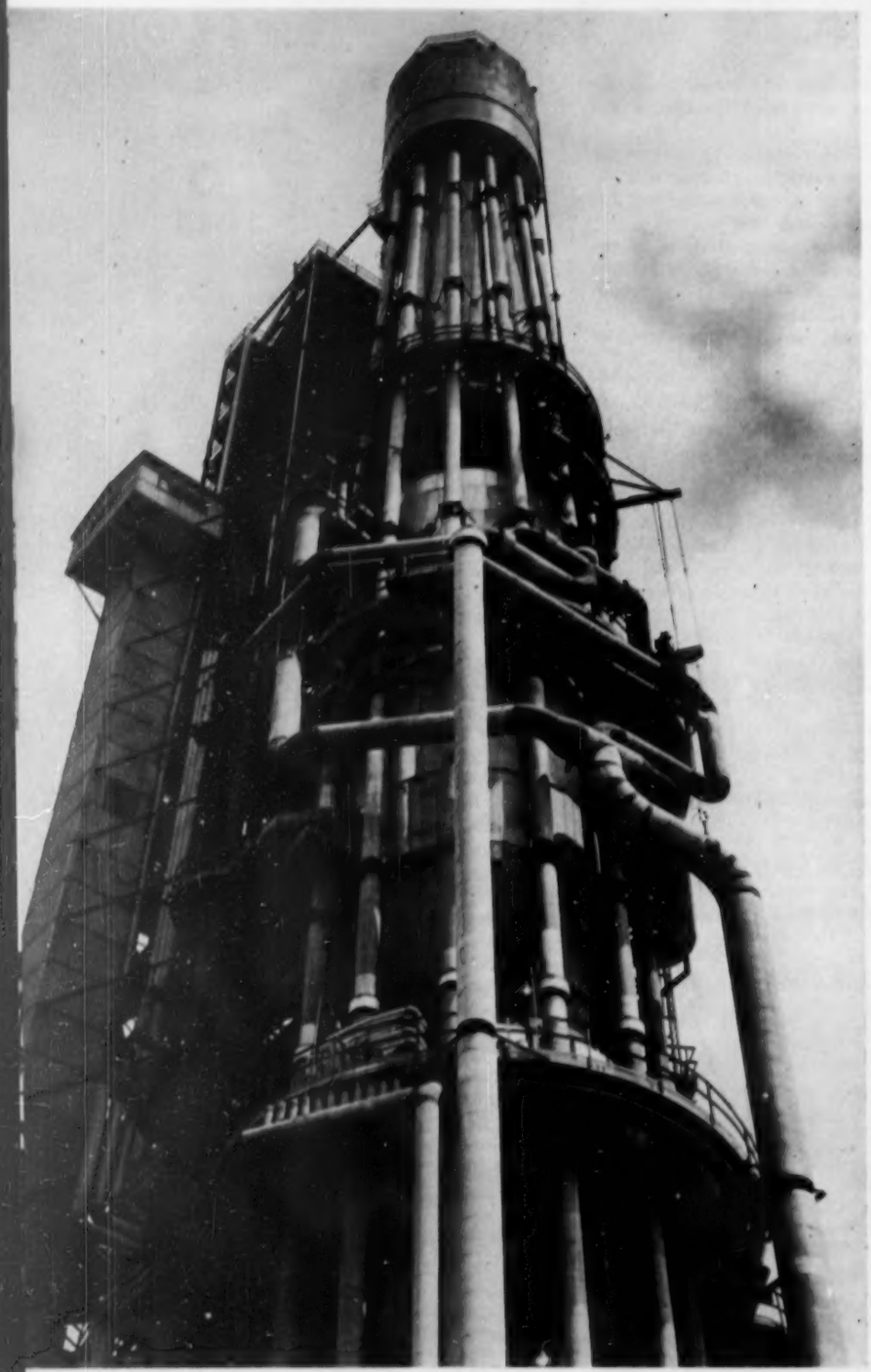
STOI at Florence is increasing crude capacity by 11,000 b/d and is building a 1,200 b/d catalytic reformer and a 600 b/d thermal reformer.

Three new refineries are projected in Italy: GOLFO near Naples, ISLOM at Gaeta, Sicily, and AGIP at Cortemaggiore.

In the Canary Islands a 10,000 b/d distillation unit and a 5,000 b/d Platformer are being built by CEPSA. In Escombreras, Refineria de Petroles is building a 23,000 b/d topping plant and an 8,000 b/d Platformer. An LPGas unit is also being installed.

Specialized installations

WESTERN HEMISPHERE



Catalyst lift lines at Sun Oil Company's newly completed 20,000-barrel Houdriflow cat cracker at Marcus Hook, Pa. The 12 lift pipes of 13-inch inside diameter raise 700 tons per hour of pelleted catalyst to the surge hopper placed at the top of the unit 350 feet above grade. The unit contains 1,400 tons of catalyst. Sun has just completed a similar cracking unit at Toledo. Cost of the two was $19.7 million.

Towers of a new hydroformer feed preparation unit at the Cities Service Co. refinery at Lake Charles, Louisiana. This unit is part of a $22 million expansion program. Fritz Henle photo.

feature refinery construction in the

CRUDE CHARGING capacity of oil refineries in the Western Hemisphere increased 385,200 barrels daily during the past year to 10,999,700 b/d. The increase was 3.5 percent, somewhat less than the expansion in hemisphere demand for refined oils.

Demand for petroleum products within the hemisphere in 1955 is estimated to require the processing of about 9,900,000 b/d of crude. Refiners in the Western Hemisphere thus would be able to take care of all consuming requirements by running at 90 percent of rated capacity.

The United States and Canada, as the largest consuming nations in the West, have the largest building program in progress on a volumetric basis. In relative terms, capacity increases of certain Latin American areas have been far greater. Chile and Brazil have become important refining nations for the first time.

The new government plant at Concon, Chile has a capacity of 20,000 b/d, equal to more than half of the nation's consuming requirements. Built for Empresa Nacional del Petroleo by The M. W. Kellogg Co., the plant is equipped with 5,000 b/d of thermal cracking and 4,160 b/d of reforming facilities. Completion was late in 1954.

A year ago, Brazil, the second largest consuming nation in South America, was refining only about six percent of its oil requirements. Combined capacity of its refineries was only 12,000 b/d. Today this has been increased nearly eightfold to 92,000 b/d. Cracking capacity has risen from 2,000 to 45,000 b/d. Elsewhere in this issue are articles describing the new 45,000 b/d government plant at Cubatao and the 20,000-barrel refinery of Refinaria de Exploracao de Petroleo Unaio at Capuava.

In the Caribbean area, Puerto Rico is building a refining industry for the first time and an important new plant is to be built in Cuba.

Commonwealth Refining Co. is building a 22,000-barrel refinery in Puerto Rico for high level conversion of Venezuelan crude. Ground was broken for the plant in November 1954 and The Lummus Co., general contractor, expects to have the plant ready for operation next December or January.

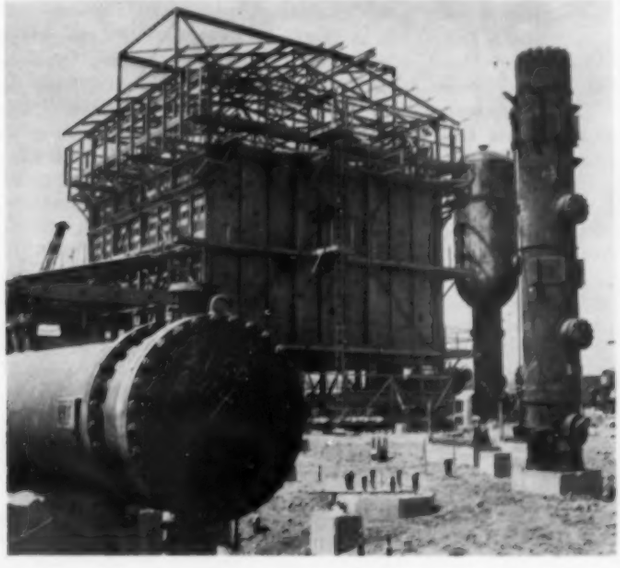
Two types of crude will be charged to stills. The company has contracted with Esso Export Co., a Jersey Standard affiliate, for the purchase of 17,000 b/d of Tia Juana crude for 10 years. A similar contract for seven years has been signed with Texas Petroleum Co., a subsidiary of The Texas Co., for 5,000 b/d of Oficina crude.

The emphasis in the new plant will be on both yield and octane of gasoline. Production of premium and regular grades of motor fuel, plus 100/130 and 115/145 grades of aviation fuels will aggregate about 60 percent of crude charge. The clear octane level of this gasoline pool will match that of any refinery now in existence.

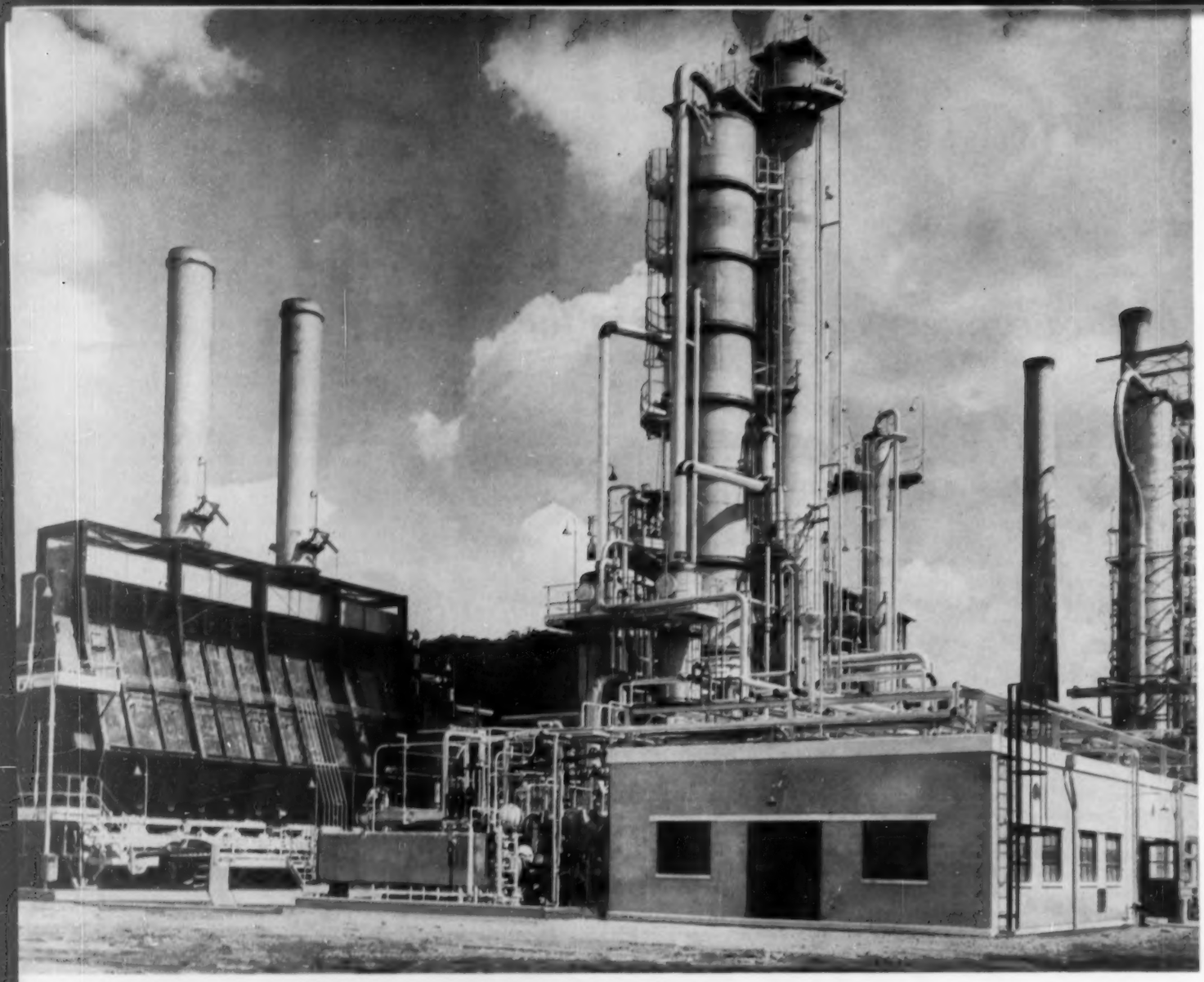
The combination crude unit is rated at 22,000 b/d, with a maximum topped crude charge of 15,000 b/d to the vacuum stage. Vacuum bottoms representing about 20 percent of crude will be blended to heavy fuel oil.

Atmospheric and vacuum gas oils comprise feed stock for the Houdriflow catalytic cracking unit which has a rated fresh feed capacity of 12,400 b/d. A high recycle

Structural work on the ammonia unit of Standard of Ohio's petrochemical plant at Lima, Ohio. John F. Trauger photo for "The Sohioan."



View of Platformer and Unifiner, showing general layout of units, at the Oleum refinery of Union Oil Co. of Calif., Rodeo, Calif.



This specially designed distillation unit was put into operation in late 1954 by The Pennzoil Co., and has a maximum capacity of 12,000 barrels of crude oil daily plus 1,500 barrels of other products for rerun purposes. It is the largest in the world devoted exclusively to the refining of 100% Pennsylvania oil.

rate will result in a total reactor feed of 24,800 b/d. This high conversion operation will produce a maximum yield of high octane gasoline. The substantial production of light fractions which will accompany the operation will be recovered in a Lummus type gas recovery system.

Straight run wide-range naphtha from the atmospheric crude tower will be processed in a 3,700 b/d Houdriforming unit producing high octane reformate for blending to motor fuel. Total plant isobutane from the gas recovery system will be alkylated to extinction with butylenes in a sulfuric acid type unit capable of producing 1,400 b/d of alkylate. Remaining light olefins will be polymerized in a unit employing the California Research method, for an output rated at 800 b/d of polymer. Conventional treating facilities will complete the processing sequence at the refinery.

The high level of conversion to be employed will permit maximum production of high octane gasolines. The two grades of aviation gasoline will run about 900 b/d. Premium and regular motor fuel production will reach about 12,200 b/d. The octane number of the pool designed for motor fuel blending will equal the anticipated East Coast octane level of several years hence.

LPGas production of the new refinery will range about 600 b/d. Kerosine output will be a minimum of 600 b/d. Diesel fuel production will approximate 1,100 b/d and heavy fuel oil will run about 6,100 b/d.

Processing units in the new plant will be well integrated to conserve heat and reduce investment in intermediate process storage. However, the plant will retain sufficient flexibility to adjust to seasonal fluctuations in yield and to long range trends in octane requirements.

The 10,000-barrel refinery of Caribbean Refining Co. near San Juan, Puerto Rico, has been completed and went on stream May 17. The plant was built at a cost of $11 million by The Fluor Corp.

The Cuban refinery is to be a 20,000 b/d plant at Santiago for which plans are being made by The Texas Co. At present Cuba has six small plants with a combined capacity of only 11,100 b/d, less than a fifth of its consuming requirements.

Mexico has continued to enlarge and modernize its refining industry. National capacity increased 25,000 b/d during the past year and even larger increases will be ready for operation in the next year or so. Most important addition to Mexican facilities during the past year was the Salamanca lube plant built for Petroleos Mexicanos by Arthur G. McKee & Co. (WORLD PETROLEUM, April 1955).

The $15 million lube plant is equipped to produce 2,200 b/d of finished oils from 14,000 b/d of reduced Poza Rica crude. Units include deasphalting, furfural extraction, and MEK dewaxing.

Later this year the Atzcapotzalco refinery at Mexico City will be enlarged from 50,000 to 90,000 b/d. At Minatitlan an old refinery is being replaced with a new 40,000 b/d plant.

Colombia is to have its refining capacity increased by more than 50 percent when

International Petroleum completes a 25,000-barrel plant at Cartagena. The installation is now being designed but will not be ready for operation until 1957. International now operates the government plant at Berranca Bermeja under contract.

Canada has continued its very active building program during the past year in an effort to keep pace with its rapid expansion in domestic demand. Consumption rose nearly nine percent to about 555,000 b/d in 1954 and is expected to approximate 600,000 b/d this year. Refinery still capacity rose 69,000 b/d in the year ended June 30 to 598,000 b/d, and this is still inadequate to meet domestic demand on a 90 percent operating basis.

By the end of 1955, Canadian capacity will rise to about 616,000 b/d and a year later will approximate 670,000 b/d after retirement of obsolete facilities. Largest new plant to come on stream this year will be the 20,000 b/d Petrofina refinery at Montreal.

Imperial Oil Ltd. will activate two important installations next year. The Halifax plant now is in process of rebuilding and expansion. The $25 million job will expand capacity to 41,625 b/d. In the West, Imperial is building a $14 million lube plant which will feature a hydrofinishing step.

Shell Oil of Canada is engaged in its third major expansion at Montreal in the past five years. The $14 million program will increase Shell's crude capacity at Montreal to 55,000 b/d and embraces the construction of several specialized units. One such will be the world's first hydro-desulfurizer for heavy cat cracker feedstock.

Canadian Petrofina is building a new refinery at Montreal and Canadian Oil Companies Ltd., Trinidad Leaseholds and others are engaged in building programs which were described in detail in the May Canadian issue of WORLD PETROLEUM.

United States crude capacity has increased 177,000 b/d during the past year to 8,420,000 b/d. The increase of two percent is only about half the normal rate of increase in demand. Currently it is estimated that domestic consumption this year will be about five percent above 1954.

Four major new refineries with a combined capacity of 240,000 b/d now are under construction in the United States. Two will be completed this year and the remaining two at the end of 1956. Combined cost will be around a quarter of a billion dollars.

Largest new plant to be completed this year will be the 50,000 b/d Shell Oil Co. refinery at Anacortes, Wash. Initial operations are planned for September with all units on stream in November. A cat cracker of new design created by Shell research is being built. Canadian crude will be delivered by the Trans-Mountain pipe line. Bechtel Corp. is builder.

In the Midwest, Great Northern Oil Co. is completing a 25,000 b/d plant at Pine Bend, Minn. Included will be a 12,000-barrel TCC unit and a 5,000 b/d Ultraformer. Completion by Fluor Corp. is scheduled for the third quarter of this year.

Last October Standard Oil Co. (Ind.) completed a new 30,000 b/d refinery at Mandan, N. D. and is now planning erection of a 6,000 b/d catalytic reformer. Completion target is the late spring of 1956.

Standard of Indiana's subsidiary, American Oil Co., is beginning construction of a 35,000 b/d refinery near Yorktown, Va. The M. W. Kellogg Co. has designed and will build major units. The refinery will include an atmospheric and vacuum crude unit, 30,000 b/d Orthoflow cat cracker, cat poly unit and LPGas recovery plant.

Largest project in the East is the 130,000 b/d refinery of Tide Water Associated Oil Co. on a 4,800-acre site near Wilmington, Del. The plant will embrace catalytic cracking and reforming units. C. F. Braun & Co. is engineering contractor.

Commerce Oil Refining Corp. has obtained a permit from the town council of Portsmouth, R.I. to build a 30,000 b/d refinery there. No contracts have been let as this is written.

Standard Oil Co. of California is developing plans to spend $25 million to $30 million to build a refinery in the Hawaiian Islands. Capacity will be 20,000 to 30,000 b/d. The project still is in formative stages.

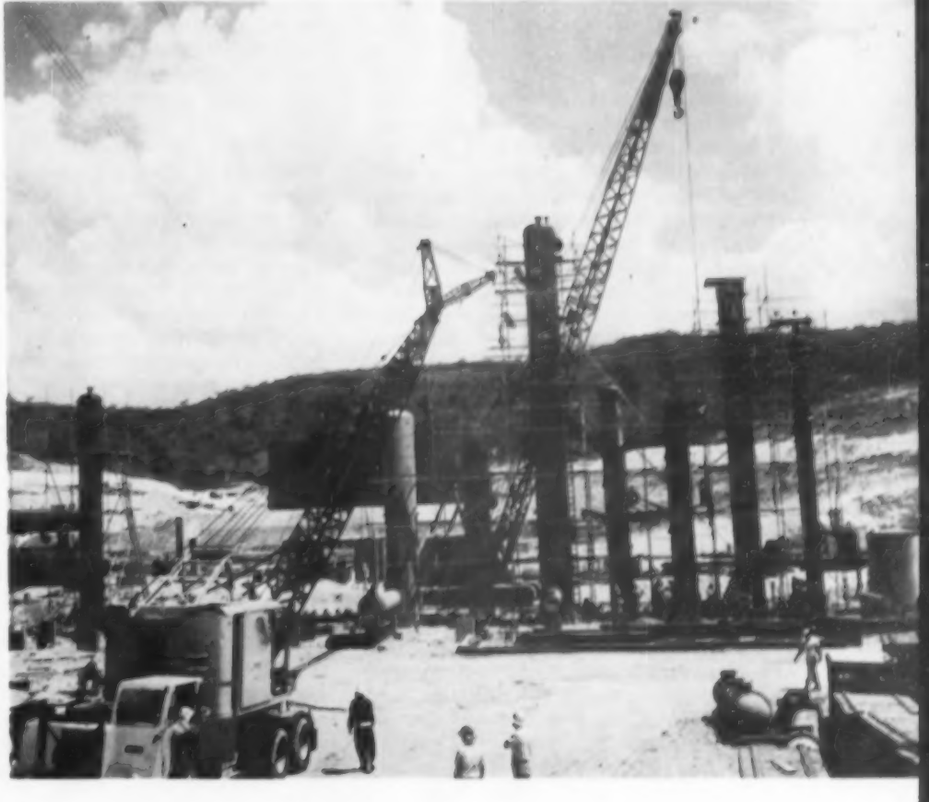
In addition to completely new plants, normal expansion of crude handling facilities has been taking place. One of the largest is the erection of a 55,000 b/d crude still by Standard of Indiana at Whiting. This will bring capacity of the plant to 220,000 b/d in 1956. A survey by the American Petroleum Institute shows operable still capacity totaling 8,275,000 b/d on September 30, 1954, 8,378,000 b/d at the end of the year and an anticipated total of 8,400,000 b/d by the end of September this year.

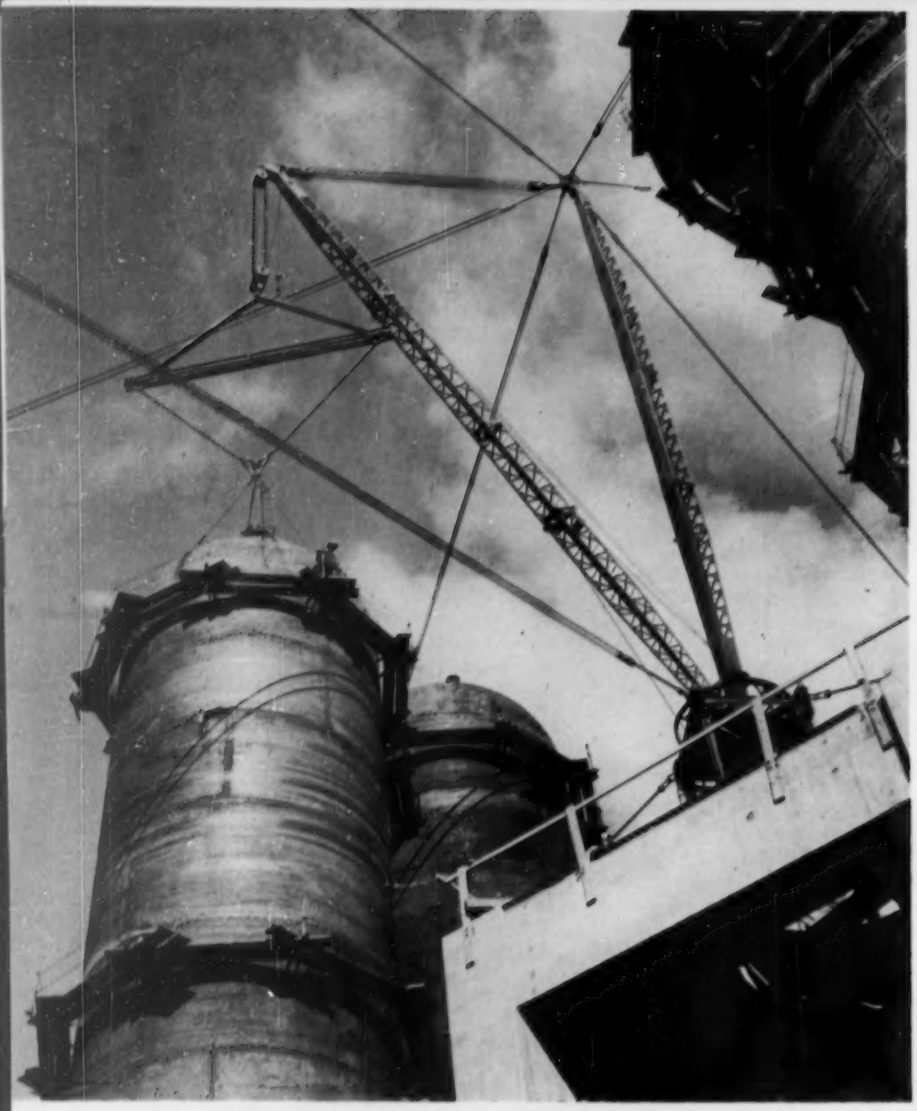
One of the most active construction areas is that of catalytic reforming. To meet the demand for higher quality motor fuel, refiners are spending hundreds of millions for reformers.

The Texas Co., for example, has recently completed three Platformers with an aggregate capacity of 45,000 b/d and is building four more which will have a total capacity of 35,000 b/d. Recent completions were at Eagle Point, N.J., Lawrenceville, Ill., and Port Arthur, Texas. Building units are at Lockport, Ill., Casper, Wyo., Los Angeles and Tulsa. Texaco also is building a 25,000 b/d furfural plant at Los Angeles.

Socony Mobil Oil Co. is also rapidly expanding its reforming facilities both in the United States and abroad. Fixed bed platinum catalyst Sovaformers are now on stream at Ferndale, Wash., and Augusta, Kans. TCR process units are in operation at General Petroleum Corporation's Torrance, Calif. refinery and at Magnolia Petroleum's Beaumont, Texas plant. Socony is building reformers at East Chicago, Ind., Paulsboro, N. J., Trenton, N. J., Gravenchon, France and Coryton, England.

Installing trays in towers at Commonwealth Refining Co. plant being erected in Puerto Rico by The Lummus Co. Photograph was taken on May 10 this year.





Construction at Shell Oil Company's 50,000 b/d Anacortes refinery. Shell photo.

Standard of Indiana and affiliates have completed a number of reformers and others are building or planned. Ultraformers have been completed at Pan-Am Southern's El Dorado, Ark. refinery and Standard's Casper plant. This year Standard's Wood River, Ill. and Sugar Creek, Mo. plants and Pan American's Texas City plants will complete units. Utah Oil Refining and Standard's Mandan, N. D., plant will begin building. A fluid hydroformer is going up at Whiting.

Gulf Oil Corp. is in the midst of a reformer construction program involving Platformers at Toledo, Philadelphia, Port Arthur and Cincinnati. Procon, Inc. recently completed the 10,000 b/d Toledo unit for Gulf. Three other units now building will have a total capacity of 46,000 b/d. At Port Arthur, hydrogen from the 29,000-barrel Platformer will be used for furnace oil treating in a "Gulfining" unit. Two 20,000-barrel units are being built for Gulf by M. W. Kellogg Co.

Esso Standard Oil Co. has completed a 20,000 b/d fluid hydroformer at Baton Rouge and is building a fixed bed unit at Baltimore. Foster-Wheeler is also building a 17,000-barrel hydrofinisher for Esso at the Baltimore plant. Affiliated Humble Oil & Refining Co. is building two fluid hydroformers with a capacity of 36,000 b/d at Baytown. Carter Oil Company's work this past year has featured the first commercial fluid coking unit. This affiliate now is planning a catalytic reformer and hydrofiner.

Sinclair Refining Company's version of platinum catalyst reforming is being installed at the company's Chicago and Houston plants. The Houston unit will have a capacity of 24,000 b/d and cost $16.5 million. The Chicago unit now operating has a capacity of 16,000 b/d.

Construction of a 15,000 b/d Ultraformer at the Pure Oil Company's Smith's Bluff refinery in Texas will begin in the late summer or early fall. The Ralph M. Parsons Co. will make the installation. Pure also is planning to start work on a new catalytic reforming unit this year at its Lemont, Ill. refinery. The company's first catalytic reformer, built by the M. W. Kellogg Co. at the Heath refinery in Ohio, went on stream last September.

Union Oil Co. of Calif. recently completed a 14,500 b/d Platformer and Unifiner at Oleum. Other building involved a 60-ton sulfur plant and a 6,500 b/d Unisol plant. At Santa Maria a new refinery, located on a 3,200-acre site, was recently placed in operation. This refinery consists of twin delayed cokers, each with a crude charge capacity of 10,500 b/d, and a combined hydrogen sulfide removal and sulfur plant. Sulfur production will be approximately 42 long tons per day.

A unique feature of the new Santa Maria refinery is the data reduction system employed to (1) record plant operating information and (2) to scan continuously the critical operating control points and to sound an alarm when any control point is outside a preset range.

Phillips Petroleum Co. will construct a third 16,000 b/d Platformer at its Kansas City, Kansas refinery. Construction, to be handled by Procon, Inc., is expected to begin late this summer with completion scheduled for the spring of 1956.

Phillips completed its first Platformer at Sweeney, Texas last September. A second will be completed this September at Phillips, Texas.

Sun Oil Co. will place a new 18,000 b/d Houdriformer on stream next month. The new $14.5 million unit will bring reforming capacity at Marcus Hook to 32,000 b/d. Hydrogen from the two units will be used to produce 300 tons per day of ammonia in a new $9 million plant which will be completed late this year. Sun now is producing 19 million gallons per year of benzene, 30 million gallons of toluene and 15 million gallons of xylenes at Marcus Hook.

Sun's modernization and refinery construction program for 1955 will cost $30 million. Although this is a continuing program, capital investment this year is 50 percent more than the $19.9 million spent on modernization and expansion last year.

In a recent announcement, Clarence H. Thayer, Sun's manufacturing vice president, reported that the world's two tallest Houdriflow units have been completed and are now in operation. One of these is in Sun's refinery in Toledo, Ohio and went on stream on April 7. The second unit began operation a month later on May 4 at Marcus Hook, Pa. Each unit has a catalytic cracking capacity of 30,000 b/d and both were completed at a total cost of $19.7 million, including all auxiliary facilities. Design innovations include integral waste heat Oxycat boilers and a circular arrangement of 12 catalyst lift pipes around the reactor-regenerator vessel.

Facilities to remove sulfur from the hydrogen sulfide present in catalytic gas are to accompany the Marcus Hook unit. A $260,000 plant designed to produce 20 long tons per day of sulfur is now scheduled for completion this September.

At the Marcus Hook installation, $4 million has been expended to install a vacuum distillation unit and revamp other existing

equipment to permit the refining of heavy, low-cost crude oils with a high sulfur content.

In addition to a four-story research laboratory completed earlier this year at a cost in excess of $1 million, ground will be broken soon for a second section of comparable size and cost.

Besides the new 30,000 b/d Houdriflow at Toledo, a $300,000 furfural solvent extraction plant will be constructed there this year. Planned to be completed and in operation by July, this plant will extract synthetic crude to make charge stock for the world's first quadruple-reactor Houdriflow, built in 1950.

Another construction project planned for Toledo this year is a $500,000 refinery laboratory which will provide more extensive facilities to check product standards and process efficiency.

Quaker State Oil Refining Corp. placed three Platformers on stream at its various refineries early this year. Combined capacity is 3,500 b/d.

Cosden Petroleum Corp., Big Spring, Texas, is now contemplating construction of a second cat reformer to bring capacity to 8,000 b/d. The cat cracker also will be revamped. Recently Cosden increased its crude capacity to 27,000 b/d and added an alkylation unit.

The Dougherty refinery at Petrolia, Pa., is building a 100-ton Miley sludge decomposition process. Two units will be in service in August and a third at the end of the year. A new 60,000 lb./hr. steam plant is under construction at the Franklin refinery, Franklin, Pa.

Other catalytic reformers have been completed recently or are under construction for The Cooperative Refinery Association at Scotts Bluff, Neb.; Danaho Refineries, Pettus, Texas; Standard Oil Co. of Texas, El Paso; Cal State Refining Co., Signal Hill, Calif.; Standard of California at Richmond and El Segundo; Hancock Oil Co., Long Beach, Calif; Ashland Oil & Refining Co., Cattletsburg, Ky.; Champlin Refining Co., Enid, Okla.; Cities Service Co. at East Chicago, Ind., and Lake Charles, La.; and Naph Sol Refining Co., Muskegon, Mich.

Refiners are active in planning to use the very large quantities of hydrogen being produced as a by-product of catalytic reforming. Uses include raw material for ammonia and pretreating of catalytic reformer charge stocks, treating of furnace oils, kerosine, special naphthas, lubricating oils and waxes. Socony Mobil has just announced a hydro cracking method of producing superior jet fuels. The next few years will be marked by a very large construction program for hydrogen utilization so that the gas need not be burned for fuel.

A number of new alkylation plants now are nearing completion. The Texas Co. has been engaged in building units at Westville, N. J., Lockport, Ill. and Lawrenceville, Ind.

Among other specialized units being built, catalytic cracking units are being enlarged or new units constructed, and with these, refiners are building feed preparation units and cokers to reduce heavy fuel production. A typical program for one of the smaller plants is that under consideration by the Cooperative Refinery Association at Coffeyville, Kans. Here the new plan envisages a 4,200 b/d Platformer, a 3,000 b/d Unifiner, and an 8,000 b/d coker. The cat cracker will be modernized at the same time.

Petrochemical activity of oil companies has involved the construction of numerous facilities for the production of sulfur, aromatics, ethylene derivatives and other chemicals and intermediates.

Near the end of 1954, Lion Oil Co. completed a new ammonia plant near New Orleans which is now producing 300 tons per day of nitrates. (World Petroleum, December 1954).

Rapid progress in the construction of Sohio's new petrochemical plant at Lima, Ohio, indicates this plant will be completed on or ahead of schedule in early November, according to Edward F. Morrill, general manager of the petrochemical department of the Standard Oil Company (Ohio).

This petrochemical plant, on a tract of land adjacent to Sohio's Lima refinery, will have a daily productive capacity of 300 tons of anhydrous ammonia, of which 200 tons will undergo further processing to make 125 tons of urea, 60 tons of nitric acid, and more than 200 tons of nitrogen solutions. These products are used as agricultural fertilizers and in the manufacturing of plastics and other industrial materials.

Earlier in this report it was noted that Sun Oil Co. is building a 300-ton ammonia plant at Marcus Hook.

Standard Oil Co. of California is planning a 300-ton ammonia plant and a 250-ton nitric acid unit at Richmond, Calif. for 1956 completion. An isophthalic plant to produce 50 million pounds per year will be completed in November at a cost of $10.9 million.

Calumet Nitrogen Products Co., a new company that will build an ammonia plant at Hammond, Ind., was announced recently by Standard Oil Co. and Sinclair Refining Co. Calumet will build a 300-ton per day anhydrous ammonia plant which will be capable of converting a portion of the ammonia to nitrogen solutions. It will be located in Hammond, Ind., near the Whiting and East Chicago refineries of Standard Oil and Sinclair. Completion and initial operations are scheduled for May 1956.

By-product hydrogen from reforming naphthas will be supplied from both Sinclair's and Standard's refineries to be used in the manufacture of ammonia.

Standard of Indiana began the production last February of isooctyl alcohol at Wood River, Ill. Annual production is 10 million pounds by a process developed from German work during World War II. The complex process involves high temperatures and pressures as well as catalytic reactions. Standard plans to produce decyl and other high-boiling alcohols.

Standard's subsidiary, Stanolind Oil & Gas Co., which purchased the Carthage Hydrocol plant at Brownsville, Texas, has been remodeling this installation and expects to begin the production late this year of alcohols and other liquid products from natural gas.

The Gulf Oil Corp. completed in June a new ethylene plant at its Port Arthur, Texas, refinery. The addition of this plant increases Gulf's ethylene capacity to about a million pounds a day, or 18 percent of the nation's ethylene requirements.

The multi-million dollar plant, which utilizes gases available from the refinery, was designed and constructed by the Badger Process Division of Stone & Webster Engineering Corp.

Ethylene from the new plant is being distributed through Gulf's extensive ethylene pipe line to a number of customers. Among the products for which it is being used are polyethylene, ethylbenzene, ethylene oxide, and tetraethyl lead.

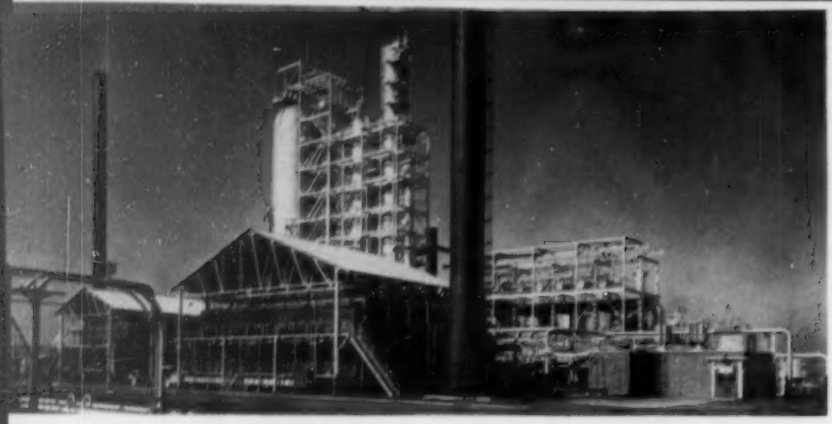
Phillips Petroleum Company's petrochemical construction activity at this time is directed toward the addition of new facilities for commercial scale manufacture of its new polyethylene, Marlex. In April, the company announced that Phillips Chemical Co. will immediately begin construction of a large plant to produce Marlex at its Adams Terminal chemical manufacturing works on the Houston Ship Channel near Pasadena, Texas, and a 145-million pound per year ethylene plant to be located at Phillips Petroleum Company's refinery near Sweeny, Texas. These two plants and the pipe line between them will represent a multi-million dollar investment.

Marlex, which is made by the Phillips-developed low-pressure catalytic process, will be sold to fabricators of a large variety of industrial and consumer products including packaging films, nonbreakable bottles, flexible and rigid pipe, molded articles, wire and cable insulation, and laminates with paper and other films.

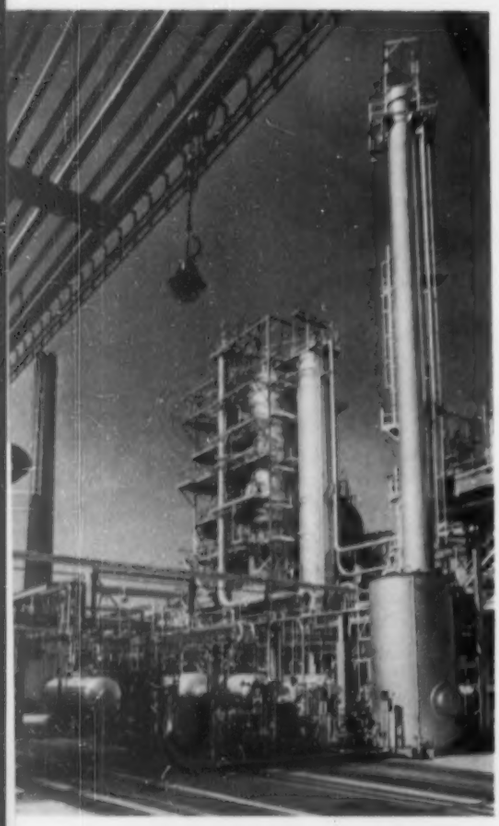
Phillips is building a new laboratory near Bartlesville especially for chemical research. Several million dollars will be spent. Phillips has been active for many years in the production of synthetic rubber, furnace black, sulfur, nitrogen and plastics.

The first step in a three-phase program for making synthetic glycerine by an entirely new method has been taken by Shell Chemical Corp. First step will be a new hydrogen peroxide plant with a design capacity of more than 30,000,000 pounds a year. The second plant, to be built later, will make acrolein. The third plant will produce the glycerine, using acrolein and hydrogen peroxide as intermediates.

All these facilities will employ new processes invented by Shell Development Co., where improved and more efficient routes to glycerine have been under investigation for a number of years. They also originated the earlier process for making glycerine from petroleum, as currently used in Shell Chemical's Houston, Texas plant which now supplies more than one-quarter of all the glycerine used in the United States.



Southwest view of the combination vacuum and atmospheric distillation unit at the Dunkirk, France refinery of Societé Française des Pétroles B.P.



Fluid catalytic cracker at the Berre, France refinery of Shell-Berre. All photos used in this article courtesy of The Lummus Company.

FRENCH REFINERY OPERATIONS ROSE FIVE PERCENT IN 1954

By Bernard Pene

DURING 1954, French refineries processed 174,218,700 barrels of crude oil and distillate, an increase of five percent over 1953. The increase was less than in the two previous years during which French still capacity was being enlarged at a rapid rate. In 1953 crude runs were 16.8 percent higher than in 1952. Operations that year were in turn 19.5 percent above 1951.

Domestic consumption of petroleum products increased 10 percent and served to compensate for the loss of foreign markets. This loss threatens to become more accentuated by the development of European refining, the opening of the Aden refinery and the reopening of Abadan.

Custom refining, exports and similar operations accounted for 8,177,000 barrels less than in the preceding year. The refined products turned out by French refineries had the following destinations:

France (including French bunkers)	71.4%
North Africa and overseas territories	11.6%
Custom refining and other exports	17.0%

Domestic consumption of petroleum products was as follows: gasoline, regular and premium, 32,896,000 barrels, an increase of 7.81 percent. Of this quantity, premium gasoline constituted 33.5 percent. Gas oil consumption totaled 9,994,000 barrels, an increase of 10 percent; fuel oils 46,691,000 barrels. This was an increase of 26 percent for liquid and 10 percent for solid fuels.

Development of consumption has been held in check by new taxes on gas oils with the object of reducing competition against the railroads by road transport and on fuel oils in order to influence the domestic market in favor of national coal. This has obliged the oil companies to limit the sales of liquid fuels to a certain tonnage.

Imports of finished products (3,201,100 barrels) included aviation gasoline of 100/130 octane, along with reduced tonnage of gasoline from Italy and Romania and low-sulfur fuel oil for metallurgic plants.

In a general way, the year 1954 marked an advance in gasoline quality. The average octane of regular gasoline passed from 75 (R.M.) in March to 77 (R.M.) in August. Since the end of 1953 the octane number of premium gasoline has been 87 (R.M.). New progress will probably be registered in 1955.

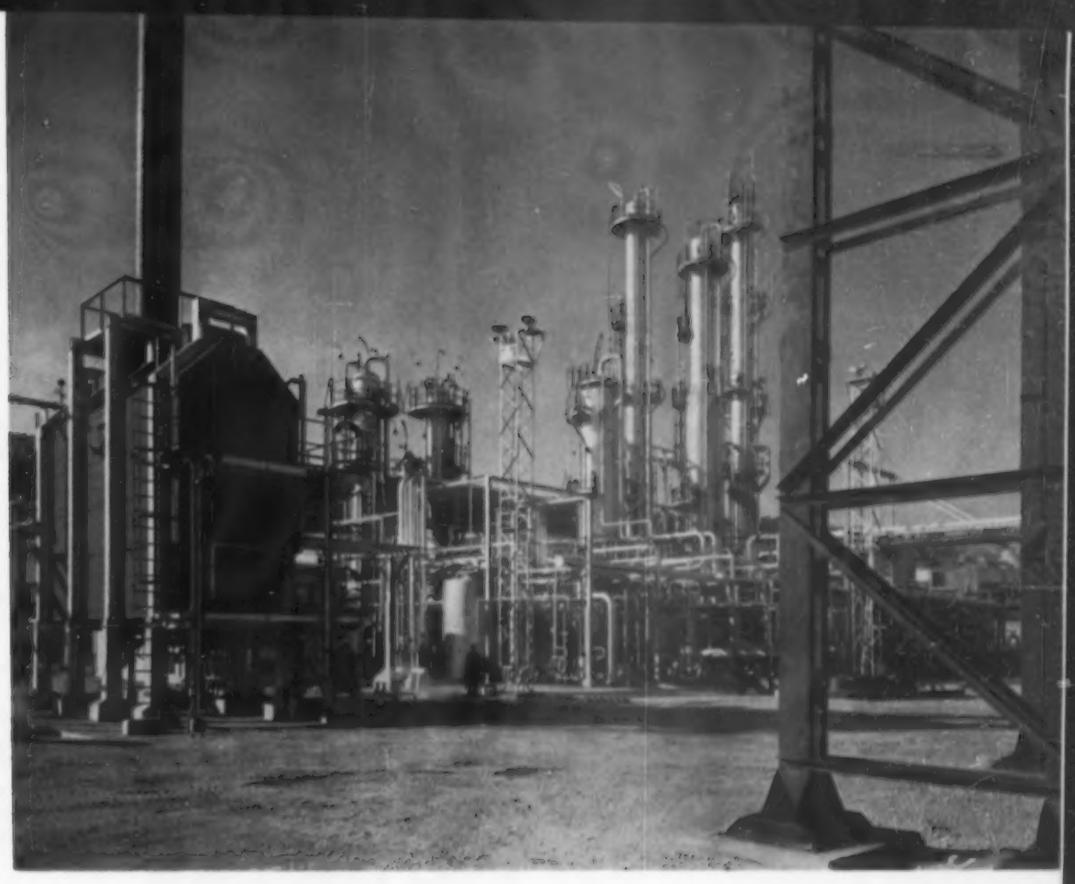
Of the 174,218,700 barrels of crude oil processed by the refineries, 169,907,800 barrels were imported, nearly all (94.1 percent) coming from the Middle East. The tonnage furnished by the Compagnie Française des Pétroles as part of its Iraq production was 32.9 percent of the crude oil run by the refineries to meet domestic requirements. It was 32.8 percent in 1952.

Exchange agreements in force during previous years have continued this year and allow payments to be made in francs for up to 40 percent for the Middle East crude oil furnished by the American companies.

The classification by origin and payments for crude oil processed for national consumption is as follows:

National crude	2.9%
C.F.P. crude	32.9%
Middle East crude (paid in francs)	9.4%
Crude from dollar sources	18.0%
Sterling source crude	36.1%
Various	0.7%

Foreign credits in important amounts, though less than last year, have been received from exports, custom refining and equivalent operations on 46,304,500 barrels of finished products, of which 19,355,000



The gas plant at the Martigues, France refinery of Compagnie Française de Raffinage.

barrels were sent to North Africa and the overseas territories.

Production of national crude oil showed a very slight advance, amounting to 2.8 percent of national needs as compared with 2.7 percent in 1953. However, there is no doubt that the year 1954 will be important in the history of petroleum prospecting in France. Esso Standard's discovery of the Parentis field in the Landes will produce about 5,100,000 barrels this year and in 1956 will certainly exceed 7,000,000 barrels of an excellent crude oil rich in gasoline with a low sulfur content. This field has not yet been completely delimited and its future rate of production has not become known.

The year 1954 has also witnessed confirmation of the possibilities of the Lacq field, which may yet produce more than the Parentis field and will profoundly change the regional economy in the next few years.

French metallurgy has practically succeeded in solving the problem presented by the high sulfur content of Lacq gas. This has enabled the Société Nationale des Pétroles d'Aquitaine to envisage exploitation of the important gas horizon situated at a depth of 3,500 meters. Realization of this project will necessitate building a desulfurizing plant, from which it is expected to obtain, by the beginning of 1957, 200 million cubic meters of gas and 700,000 tons of sulfur, with an additional production of 100,000 barrels of gasoline and 7,400 tons of liquefied gas. This very important source of energy will favor the creation of new industries and raise the standard of living in southwest France, which is now one of the least prosperous regions of the country. Exploration has been pushed in other parts of Metropolitan France and various regions of the French Union, but have not given results comparable to those obtained at Parentis and Lacq.

The year 1954 has also been notable for an effort to rejuvenate and enlarge the French fleet of oil tankers. Numerous tankers with average capacities of 30,000 tons and built for the most part in French ship yards have been put in service by the French companies in the business of transporting oil. In 1954 a tonnage of 96,360,000 barrels of crude oil was imported in French vessels, corresponding to 78 percent of the needs of Metropolitan France, 68 percent of the needs of the French Union and 55 percent of total imports. On January 1, 1955 the French petroleum fleet could count 84 ships with a total deadweight of 1,450,000 tons. It is expected that this will increase to 2,000,000 tons by the end of 1957.

Among the principal new installations of refinery equipment, mention may be made of a distillation unit at Port Jerome, a Platforming unit at Lavera and a thermal cracking unit at Donges. Installations for petrochemical operations have continued to be developed, notably at l'Estaque (Standard Kuhlmann) where a supplemental distillation unit has been put on stream, and at Donges (Atlantic Progil Electro-Chimie) where construction of a unit for producing cumene from refinery gas has been completed.

Esso Standard's refinery at Bec d'Ames is the scene of considerable construction work at this time. A fluid cat cracker with a capacity of 5,150 b/d is being built. A vacuum still of 7,100 b/d capacity will provide feed stock. A 600 b/d cat poly unit and gas recovery system are being erected along with various supplementary facilities.

In the petrochemical field, perchloroethylene, used largely in the manufacture of dry cleaning and degreasing agents, will constitute the major product of a new plant at St. Auban to be designed and engineered by Scientific Design Co., Inc., New York, for Pechiney, one of France's principal chemical manufacturers. This plant will be based on the direct chlorination of ethane, methane, or propane. Its HCl by-product is earmarked for an expanded program in vinyl chloride production.

Pechiney's new plant at St. Auban will be the first in France to employ the direct chlorination process. According to Scientific Design, fundamental engineering and design features will be based on a study of a pilot installation by Montecatini of Italy. Principal differences will be the larger scale production and the purity of by-product HCl, which must be higher when used in the manufacture of vinyl chloride.

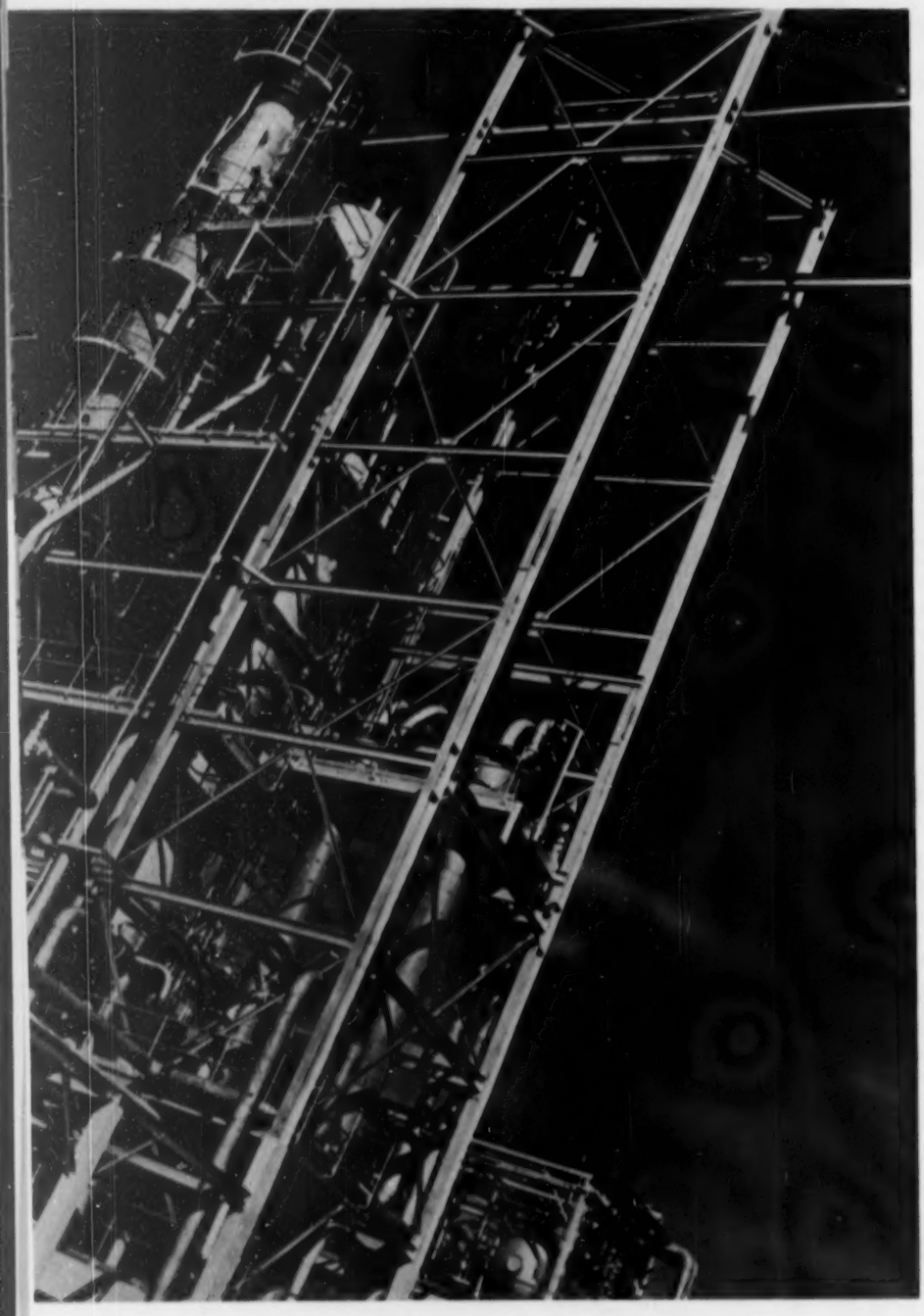
Perchloroethylene has advantages over carbon tetrachloride as a dry cleaning agent. Like carbon tetrachloride, it is suitable for the small inexpensive cleaning units now widely used in the industry. Unlike carbon tetrachloride, its vapor pressure and freezing point are low, and it is unlikely to choke a processing system. Toxicity is also well below that of carbon tetrachloride, and its odor is less apparent.

France has a rather highly developed petrochemical industry as a result of teamwork between oil refiners and specialized chemical firms. Products currently in production include phenol and acetone, cumene, ketones, alcohols, teepol for detergents, ethylene derivatives and ammonia.

GREAT BRITAIN

British refinery output continued to increase in 1954, permitting a substantial expansion of export trade.

First of its kind to be built in the world, this £1,000,000 hydrodesulfurizer, which removes sulfur from petroleum products by the "trickle" technique, has just come into operation at Shell's Stanlow oil refinery in Cheshire.



By E. Lawson Lomax

THE PETROLEUM refining industry in the United Kingdom increased its output 10.6 percent in 1954, according to figures issued by the United Kingdom Petroleum Industry Advisory Committee. Production of petroleum products from imported and indigenous crude and other oils, including those derived from oil shale, have risen as follows:

1952	22,490,363	Long Tons
1953	25,395,959	" "
1954	28,077,765	" "

Since rated refining capacity in the U.K. is just over 30 million tons, it will be seen that refineries have been running at over 90 percent capacity. This high rate can only be attained if markets are able to take the products and upkeep of plant is of such an order that it can be maintained in full production for long periods. Turnarounds must be well organized so that non-operating time is at a minimum.

Inland consumption has also risen during the past three years, but at a rate slightly less than the increase in refinery output. Following is the record:

1952	17,510,285	Long Tons
1953	19,002,695	" "
1954	21,038,511	" "

Differences between inland consumption and total production show that the U.K. is increasing its net export of refined products, and that except for aviation fuel and certain specialties, the country is more than self-supporting in refined products. Net exports have risen about one million tons per year and in 1954 represented a third of domestic refinery output.

It is estimated that total export of petroleum products in 1954 was valued at about £85 million, as compared with those of coal valued at about £67 million, which prewar was one of the country's traditional exports, and these figures are in face of the unit value of petroleum products which has only risen about 128 percent since 1939 compared with an increase of 430 percent for coal.

The pattern of refinery yields shows a gradual change over the three years as increased capacities of facilities have permitted a greater production of light products as indicated in Table I.

TABLE I

PRODUCT YIELDS AT UNITED KINGDOM REFINERIES
(Percent)

	1952	1953	1954
Motor & Light Spirits	22.0	24.6	25.4
White Spirit	0.3	0.2	0.4
Burning Oil	2.5	1.9	2.4
Vaporizing Oil	0.2	0.3	0.2
Gas/Diesel Oil	17.2	16.9	14.9
Fuel Oil	44.9	42.3	40.5
Refinery Fuel Consumption	5.5	5.9	6.8
Bitumen	3.2	2.8	2.9
Paraffin Wax, Scale & Slack Wax	0.1	0.1	0.1
Lubricating Oil	1.5	1.4	2.1
Propane and Butane	0.1	0.2	0.2
Miscellaneous products & loss	2.5	3.4	4.1
	100.0	100.0	100.0

TABLE II

AUTOMOTIVE FUELS PRODUCED FROM COAL and SHALE
(Long Tons)

	1952	1953	1954
Motor gasoline (by low temperature carbonization)	Nil	1,186	2,623
Motor and aviation gasoline (by hydrogenation)	108,899	109,520	108,185
Refined Benzole	175,493	233,622	260,058
	284,392	344,328	370,866

Production of motor and aviation gasoline from petroleum and other raw materials has been as follows during the past three years:

1952 ..... 5,219,810 Long Tons
1953 ..... 6,587,683 " "
1954 ..... 7,495,830 " "

The production for 1954 leaves a margin of about 2.5 million tons for export, internal consumption being just under five million tons.

A feature of the home sales market in gasoline is the increasing demand for premier grade coupled with a decreasing demand for standard grade. In 1953 the proportions were premier grade 42.5 percent, standard 57.5 percent, while in 1954 they were premier 47.5 percent, standard 52.5 percent.

The inland consumption of lubricating oil and greases has shown a gradual increase in the past three years, which can be accounted for by an expansion in industry and transport; but the increase in internal production has been much larger. In 1952, U.K. production was about half of the country's requirements, but in 1954, the country's requirements were met to the extent of about 70 percent by local manufacture, leaving only about 30 percent to be satisfied by imports.

This change is due to the fact that the lubricating oil sections of the new refineries, which were the last portions to be completed, are now largely in full operation.

While the percentage production of fuel oil from the crude processed has gradually decreased since 1952, the amount used internally has appreciably increased, particularly in industry. Because of the high prices of coal and tight and uncertain supplies, industrialists are being more and more converted to the use of fuel oil, with its increased cleanliness and ease of control.

One of the outstanding instances of this during the past year was the decision by the British Electricity Authority to equip its new 300,000 kw power station at Marchwood, about six miles from the Fawley refinery, for dual firing on oil or coal, which will mean the consumption of about 350,000 tons of fuel oil per year. Another instance was the agreement made between the South Eastern Gas Board and the British Petroleum Company to install a plant at the latter company's Kent refinery for the catalytic gasification of oil, the gas produced being distributed through the present distribution system of the gas board. The immediate scheduled consumption of oil for this purpose is about 50,000 tons per year, rising eventually to 150,000 tons per year.

There is an increased consumption of kerosine, which probably stems from the same source, i.e. indifferent coal supplies. Small domestic oil heaters are becoming more popular, particularly in the south of England which has a smaller coal allowance per house than in the north.

The consumption of bitumen has increased and will probably increase further in the future, owing to the decision of the government to tackle the long-delayed question of motor roads in the country, a question which calls for immediate and comprehensive action if the increasing congestion on all roads has to be slowed down, and adequate roads provided for the fast growing needs of commercial transport.

The Fawley refinery of the Esso Petroleum Co. Ltd., with its 6,000,000 tons per annum capacity, is the largest in the U.K. It was opened in September 1951, and during its first three years of operations processed about 18,250,000 tons of crude oil, mainly produced from Middle East fields.

The yields of the principal products from these operations have been of the following order: gasoline, 5,600,000 tons; kerosine, 600,000 tons; and gas and fuel oils, 10,500,000 tons. In addition, during the past year, since the lubricating oil plants went on stream, an appreciable quantity of various types of lubricants has been manufactured.

Approximately 3,200,000 tons of finished products were exported, a contribution of about £27 million to the nation's balance of trade.

The erection of the whole of the refinery plant envisaged in the original program was completed by the end of 1953, but since that time further units have been erected and put into commission, while still more units are under construction or scheduled for construction at time of writing.

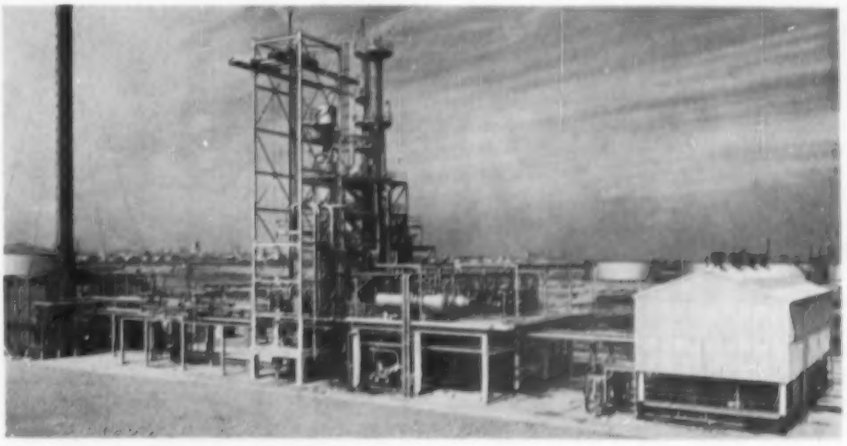
The erection of a naphtha stabilizer was completed in February 1955. This plant is used for the processing of virgin naphtha from the atmospheric distillation units in order to extract from it an additional quantity of butane for bottling as liquid petroleum gas, the stabilized naphtha then being blended in the gasoline.

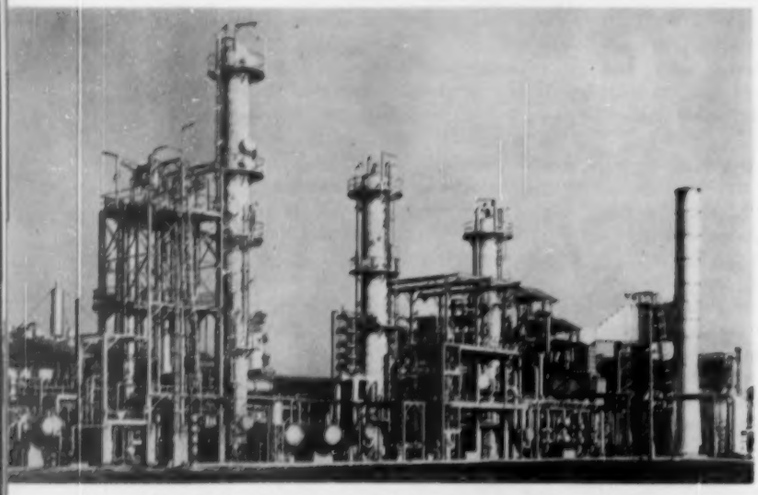
A polymer re-run unit was completed and put into commission in January 1955, being an addition to the existing polymer plant for re-running the polymer to the necessary distillation range for blending in the gasoline and also to produce C_{12} polymers for the manufacture of detergents.

A new vacuum distillation unit is being erected and is due for commissioning this month. It will provide further feed stock for the lubricating oil plant and for the cat cracker.

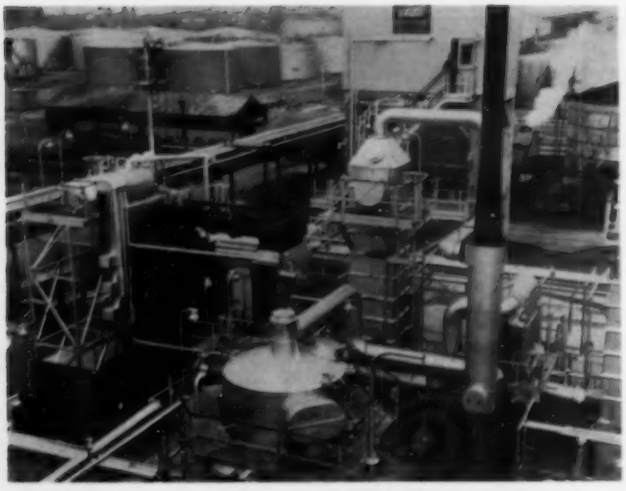
A fluid hydroformer with a capacity of about 10,000 b/d is being installed at a cost of £4 million and is due for operation in 1956. This unit is designed to produce a largely aromatic reformate from a special-

Another view of Shell's new hydrodesulfurizer, developed by the Royal Dutch/Shell Group's research organization at Amsterdam.





This 250,000 tons per year Platforming unit at British Petroleum's Kent refinery on the Isle of Grain produces a high grade motor spirit component by a reforming process using a platinum catalyst.



Sulfur extracted by the Girboltol unit is passed to this sulfur recovery unit for conversion to raw sulfur at British Petroleum's Grangemouth refinery.

ly prepared virgin naphtha cut. In addition to the reformate produced, hydrogen in a sufficient state of purity for other refinery operations is produced.

The erection of these plants involves an increase in the existing auxiliaries which were planned for the original refinery program. An extra amount of cooling water is necessary, and to provide this a new salt water pumphouse is being erected at the jetty, and a new 60-inch salt water line is being laid to the refinery. The original steam raising plant is being considerably increased to cope with the larger steam requirements, and an additional electric generating plant is being installed.

To augment the existing fresh water supply, a 22 million gallon reservoir is being made, which will be fed by a catchment scheme which traps surface water from the undeveloped portion of the refinery site. In addition, 36 miles of 24-inch pipe line are being laid from the River Avon at Christchurch.

The provision of these new plants calls for a greater capacity of oil/water separation of the refinery effluent, and so a duplicate separation plant is being built adjacent to the original one. This increase will also allow these plants to carry out the recommendations of the Faulkner report on oil pollution for which arrangements were made before the Oil in Navigable Waters Bill became law.

Two ballast water tanks have been installed near the marine terminal for the reception of oil water discharged from ships arriving in ballast, and also a slop barge into which oily water can be pumped when it is inconvenient to bring a vessel alongside a berth. The barge then discharges into the ballast tanks and thence through the oil-water separators. A berth is available for the reception of oily slops from vessels proceeding to repair ports.

These facilities are available to vessels other than those operated by Esso Petroleum Co.

The cost of the whole of these extensions is estimated to be about £10 million.

The avoidance of air pollution to preserve local amenities has also been taken up vigorously. Normal combustion products from refinery furnaces are released at a height of 250 feet above ground, and surplus gases are burnt at approximately the same height at the safety flare stack.

Two deodorizers have been installed to eliminate the smell from the spent chemicals resulting from the refining processes. Hot flue gases are fed in at the bottom of a column and scrub the chemicals. The malodorous gases thus produced are burnt in a furnace.

In addition to the strict measures which have been adopted to prevent water and atmospheric pollution, the company decided in the early stages to plant a tree belt of 5,000 trees around the landward perimeter of the refinery. All this planting has been completed, and it is very evident from the present state of growth that in the near future this tree belt will present a very adequate and attractive screen.

The company's 500-seat cinema has now been made open to the general public, which concession has been much appreciated locally.

British Petroleum Company refineries: The throughput of the Kent refinery in 1954 was 4,064,000 tons as against 2,792,000 tons in 1953. In the middle of 1954 the lubricating oil plant with a capacity of 2,400 b/d was commissioned, and produced 37,000 tons by the end of the year. Early this year a Platformer of 5,000 b/d was put into commission.

At the Llandarcy refinery the throughput for 1954 was 3,715,000 tons as against 3,883,000 in 1953. The capacity of the lubricating oil plant was increased to about 1,700 b/d when the full plant came into operation. A Platforming unit of 5,000 b/d capacity was brought on stream in April 1955.

At the Grangemouth refinery the throughput was 2,624,000 tons in 1954 as against 2,493,000 tons in 1953. A catalytic polymerization unit and a Girbotol unit came into operation in mid-1954, one section of the poly unit producing polymers as an intermediate for detergent manufacture. A sulfur recovery plant was commissioned in the autumn of 1954 and is now producing at a rate of 3,000 tons per year.

At Balfron, on the 60-mile pipe line from the B. P. tanker unloading depot at Finart on Loch Long, a boosting station was completed, raising the capacity of the line to 70,000 b/d.

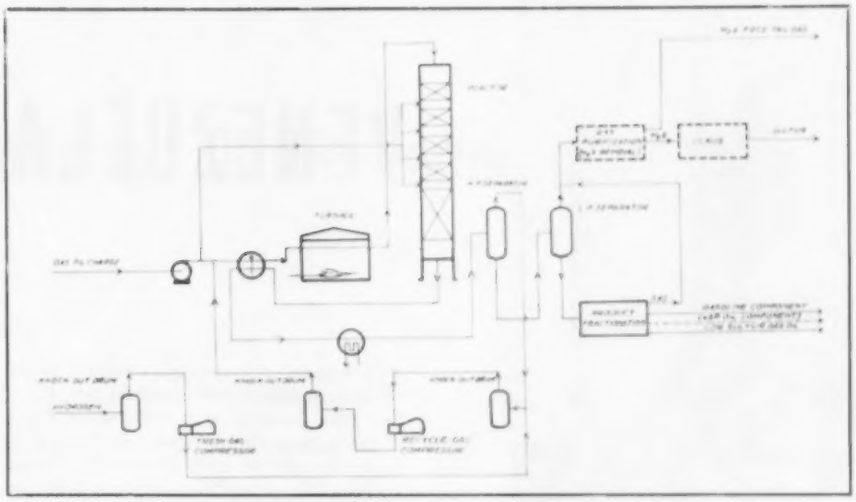
No changes were made at the Pumpherston refinery which processes indigenous crude oil and oil produced from shale.

The total throughput of these four refineries in 1954 was 10,563,000 tons as against 9,327,000 tons in 1953.

British Petroleum Chemicals Ltd.: At Grangemouth the production of industrial alcohol was increased during the year, and new schemes are in hand for largely expanding the output of petroleum chemicals.

At the adjacent plant of Forth Chemicals Ltd., which is at present the only bulk source of styrene monomer in the U. K., progress is being made with plant extensions, and provision has been made for an even larger extension than was announced last year.

Grange Chemicals Ltd. was formed during the past year in conjunction with Oro-



Simplified flow diagram of the hydrodesulfurizer at British Petroleum's Stanlow refinery.

nite Chemicals Ltd., a subsidiary of Standard Oil Co. of California, which will produce and market intermediates used in the manufacture of synthetic detergents.

Shell Petroleum Co. Ltd.: During the year, the erection of an "Epikote" resin plant was commenced at Shell's Stanlow refinery and is scheduled for completion by the end of 1955. It will be the first such plant to be erected in the U. K.

A plant for the production of iso-pentane was erected and put into commission. Erection began in July 1954 and was completed early in 1955 at a cost of £500,000, being the first plant for this purpose to be erected in the U. K.

A plant to produce 33,000 tons of sulfuric acid a year was erected at a cost of £200,000.

In addition, a new hydrodesulfurization plant, based on an entirely new process developed in the Royal Dutch/Shell research laboratories at Amsterdam, was erected and commissioned. The cost was £1 million.

Investigations in these laboratories showed that the cost of hydrodesulfurization of oil distillates is appreciably reduced when the amount of recycle gas is decreased, and that reduction of the amount of cycle gas below the conventional level will result in operating conditions under which most of the feed is no longer vaporized, but remains in a liquid state.

A high degree of desulfurization can, however, be obtained with a relatively small amount of hydrogen by using a procedure under which the oil is allowed to "trickle" over a solid catalyst in a hydrogen atmosphere. Under these conditions catalyst activity is not impaired. It was found that this technique can be applied to a variety of materials and catalysts of different nature.

There is also a saving in capital and operating costs, by reducing the capacity and power consumption of the hydrogen recycle compressors, reduction in heat transfer surface area and size of the fired preheater.

The plant was designed for the desulfurization of light catalytic cracked cycle oil and the cobalt-molybdenum-alumina catalyst used in the process was developed especially for high selectivity, i.e. very little hydrogenation of aromatics even at a high degree of sulfur removal.

During its early run the desulfurization was 90 percent or over with feed rates varying between 5,000 b/d and 7,000 b/d.

Operation of the plant is as follows: the hydrogen to be consumed during the desulfurization reaction and the hydrogen-rich recycle gas, used for catalyst protection, are compressed to the operating pressure with separate compressors. The compressed hydrogen-rich gases are combined with the major part of the charge stock and pass through the feed product heat exchangers and reactor charge heater to the reactor. The remaining part of the charge oil is fed cold to the reactor to control the heat of reaction.

The reactor products, consisting of hydrogen, light hydrocarbons, partly vaporized desulfurized cycle oil and hydrogen sulfide, pass through the reactor feed heat exchanger, then through a cooler and into the high pressure separator, where hydrogen-rich gas is separated, which is recycled or bled to the fuel system after scrubbing with diethanolamine as required.

The high pressure separator liquid is then flashed to the low pressure separator, the liquid bottoms going to the fractionating system. This section consists of a fractionating tower with two side strippers, the desulfurized product being split into three fractions, i.e. gasoline component, vaporizing oil component and low sulfur gas oil.

The re-boiler heat for the side stream strippers is supplied by a slip stream taken from the tower bottom stream, and a re-boiler furnace supplies heat to the main column.

The overhead non-condensible gases are combined with gases from the low pressure flash separator, and then are treated for hydrogen sulfide removal, the sulfur free gases passing to the refinery fuel main. The hydrogen sulfide is treated by the Claus process for the manufacture of sulfur.

The reactor contains in total nearly 25 metric tons of catalyst divided over six beds. A two-foot layer of ceramic balls is added on top of the upper catalyst bed as a scale catcher. At a throughput of 5,500 b/d, the surface velocity amounted to 1.27 vol./vol.hr. and at 7,000 b/d to 1.59 vol./vol.hr.

The gasoline component, boiling up to 220°C, is highly aromatic and has a clear octane research number of over 100. It amounts to five percent by weight on the feed, and has a very low sulfur content. The second side stream, boiling between 220-260°C, has a much lower sulfur content than expected. Sulfur content of the 260°C, bottoms of the column is 0.3 percent.

Shell Haven refinery: The erection of a Platformer was commenced in June 1954 and is scheduled for completion by the end of 1955. The estimated cost is £2,500,000. It is designed to produce 240,000 tons per year of high octane components for blending into premium grade gasoline, and is the second to be built by Shell in the U. K.

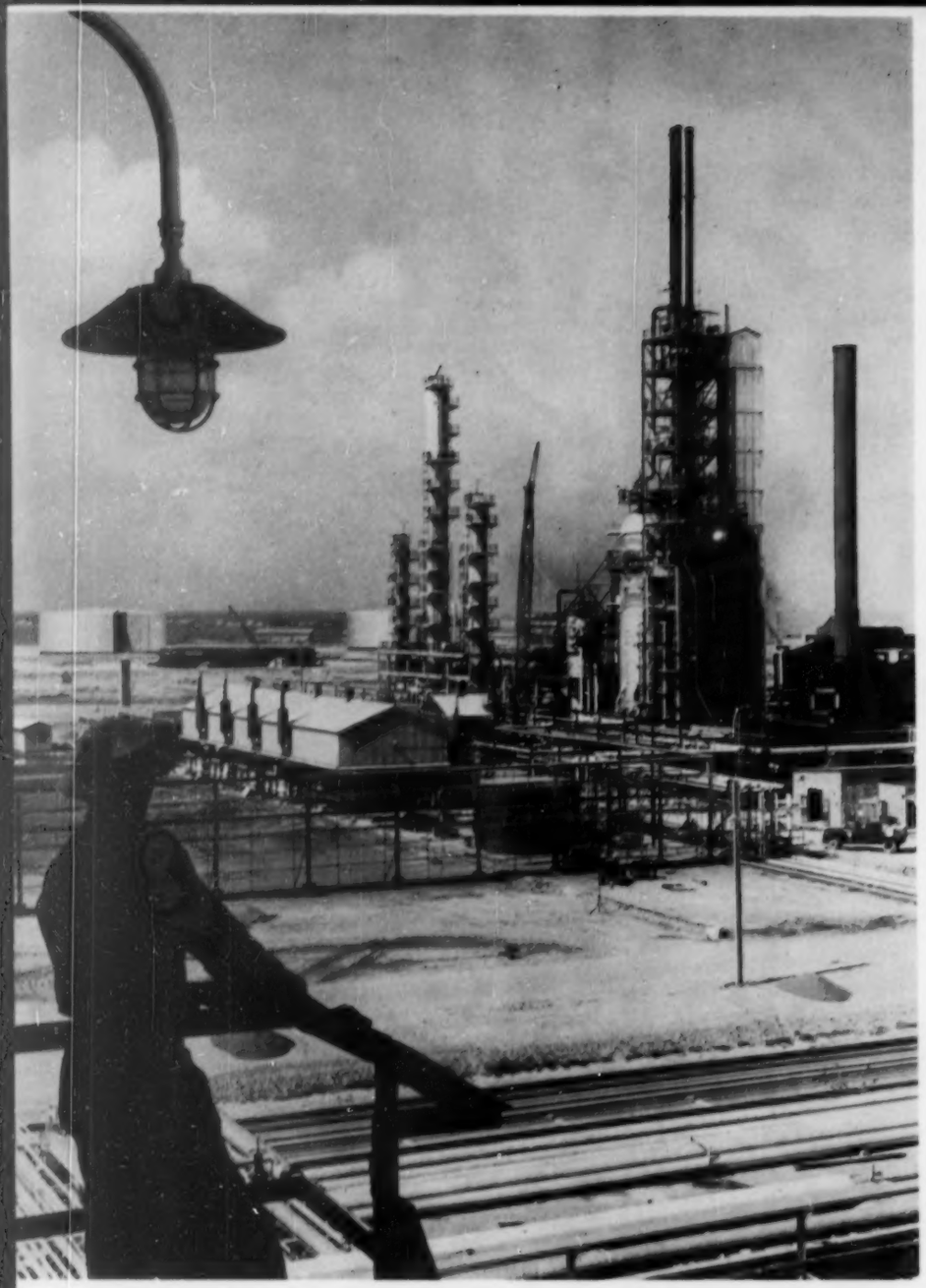
The erection of the LPGas plant was begun in September 1954, to include fractionation plant, treating plant, storage, bottling and bulk loading and is due for completion in mid-1955. It will produce 10,000 tons per year of butane and propane and is costing £300,000.

Manchester Oil Refinery: This company concentrates its activities on specialized petroleum products and the year's developments have been on these lines with no major alterations to the existing equipment. A fully automatic lube oil blending plant has been installed and increased covered drum storage built. A special "passivated" transformer oil has been developed.

Plans have been drawn up for the manufacture and marketing of oil soluble sulfonates, and plant for this purpose is to be installed. A machine shop is being installed for testing cutting fluids under actual working conditions, and the range of petroleum based inks for the non-destructive testing of constructional materials has been extended.

Trafford Chemical Developments Ltd.: This company was formed to produce specialized fine chemicals from petroleum and a plant for this purpose is to be erected. At present a number of alkyl pyridines are being made.

Berry Wiggins & Co. Ltd.: All extensions and alterations at the Kingsnorth and Weaste refineries have been completed.



Hydroformer unit at Amuay Bay as construction neared completion. In the foreground is the compressor building and behind it are the fractionating towers and the catalyst equipment structure. Creole photos.

VENEZUELA

VENEZUELA is currently refining over half a million barrels of oil per day—four times as much as in 1948 and six times as much as in 1945, at the end of the war. In the period 1948-1954, the yearly increase in capacity averaged 26 percent. In 1954, the increase slowed down to 7.4 percent. However, new units put on stream in late 1954 and early 1955 brought the February average this year up to 505,000 b/d, or 15 percent over the year 1954, and capacity was still being added at that time. (See tables I and IV on page 92.)

Expansion and improvement have been continuous in this burgeoning industry. Venezuela's two major plants were both originally designed for 60,000 b/d when they went on stream in 1950. One is now handling 180,000 b/d; the other, nearing the end of its latest expansion program, is crowding 150,000 b/d. The ultimate capacity of either is impossible to predict.

At the moment, no immediate further new plant or expansion has been announced. However, two big new projects, one of them a refinery and the other a complex of plants in the related field of petrochemicals, are looming on the horizon.

A company operating in Barinas purchased land at Puerto Cabello two years ago for an eventual refinery and deep-water terminal site. The pipe line has not yet been laid, but the survey was made several years ago, and the refinery construction would seem to be only a matter of time.

The only other company drilling in Barinas has recently announced that it has 66 million barrels of reserves in that area, and sooner or later this too will have to find a market.

The petrochemical plants, also in the vicinity of Puerto Cabello, will be a reality by 1957, according to official sources. This is a project of the Venezuelan government, which has earmarked $30 million for the purpose.

The establishment of a petrochemical plant and refinery at Puerto Cabello, in the center of Venezuela's northern coastline, would make for a more even geographical distribution of refining capacity, which is now contained in two clusters at opposite ends of the country. The heaviest concentration, 300,000 b/d in 1954, is in the Lake Maracaibo region, logically enough, since about 70 percent of Venezuela's production comes from Western Venezuela fields. The

refining 500,000 barrels per day

two greatest plants, with a combined throughput of 256,000 b/d in 1954, are located within a few miles of each other on the sandy wastes of the Paraguana Peninsula.

Since almost 80 percent of the product is destined for export, all the plants shown in Table IV are located on or near deep water: Punta Cardon and Amuay Bay, on Paraguana; San Lorenzo, on Lake Maracaibo; Caripito, on the San Juan river of Eastern Venezuela; the Vengref and Sinclair plants, at Puerto la Cruz; and the Tucupita plant, in the delta of the Orinoco. The small Phillips plant at San Roque is within 60 miles of Puerto la Cruz, but its products, including paraffin used in candles and as a seal for containers, are consumed within Venezuela.

Oil refined in Venezuela in 1954 amounted to 162,115,000 barrels, or 444,150 b/d. This was a 7.4 percent increase over the volume refined in 1953 and a 370 percent increase over 1948.

The gain in refining throughput was evenly matched by a 7.3 percent gain in barrels produced, so that the percentage of Venezuelan crude refined in the country was exactly the same, 23.4 percent, in both 1953 and 1954. This was almost three times as great a proportion as was refined domestically in 1948.

No all-new plants were constructed in 1954, and seven companies continued to operate the eight major plants. Shell's two accounted for 48.5 percent of total throughput in 1954, Creole's two for 33 percent. Besides the plants listed in Table IV, three companies ran small specialized units producing less than a thousand barrels per day each, all used in company operations. Of these, Mene Grande's topping plant at Oficina was shut down in 1954, and only Shell's Colon and Socony's Guario plant remain.

The principal additions to existing plant in 1954 were made at Creole's Amuay Bay refinery. Among these was a 10,000 b/d fluid hydroformer of advanced design. Outside the United States, where there are three such units, there are in the world only this one of Creole's and one in Japan. Standard Research & Development was the designer of this unit, which converts a low-octane, heavy-naphtha feed into high-octane fuel for automobiles and planes.

Besides the hydroformer, the 1954 addition to Amuay included a 70,000 b/d atmospheric and vacuum unit, partly to expand output of middle distillates. With the recent changes, Creole's total investment in Amuay is now about $150 million.

Is the end in sight? Not according to Creole Petroleum's policy as stated in a speech by Director Harry Jarvis to the Venezuelan Chamber of Commerce. He pointed out that there had been a tremendous upsurge in refinery construction all over the world, and that each plant built in a country where Creole has customers tends to reduce the sales outlets available to Creole. Nonetheless, Creole's view is basically optimistic, he said, in view of rising world demand for oil and oil products, and Creole expects that it will be necessary from time to time to construct new plants and make additions to those existing, in order to keep their products competitive.

Fuel oil is still Venezuela's principal contribution to the world market, as Table V shows. The fuel oil yield was almost constant at 56.5 percent in both 1953 and 1954. Seven years ago, before additions to cracking facilities, it was 70 percent, and three years ago it was still about 60 percent. (In the United States, the yield of residual fuel oil has been about 19 percent).

Gas-oil production rose 2.3 percent to 6.3 percent in 1954, while kerosine produc-

A general view of the Amuay Bay refinery, taken from the west. In the center is the No. 2 vacuum unit under construction. At far left may be seen the light ends fractionating unit.

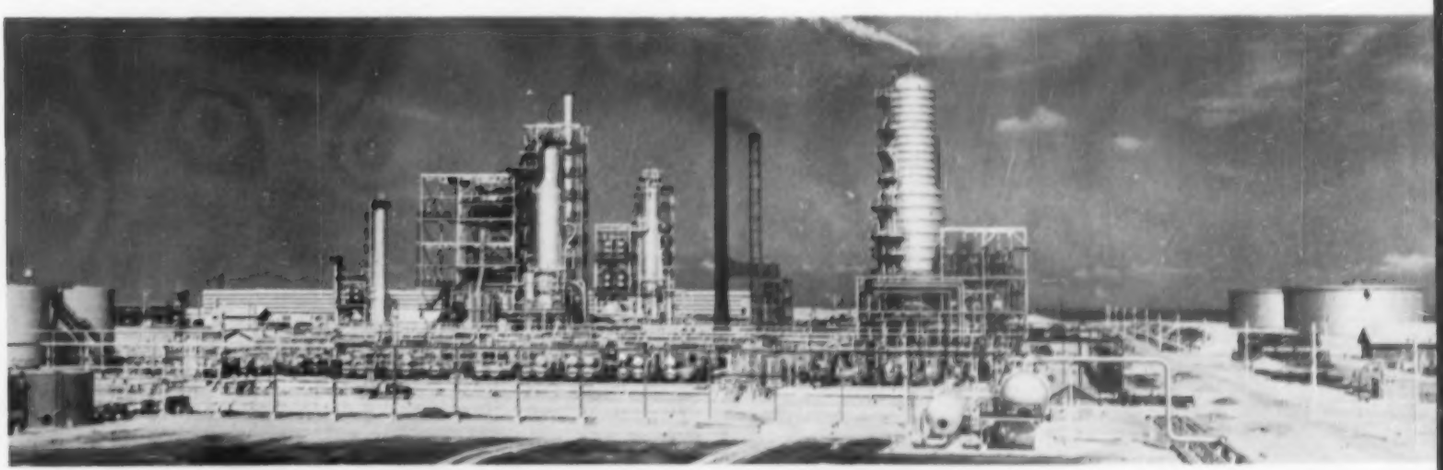


TABLE I

Refinery Growth in Venezuela

Year	Total Bbls. Refined	Bbls./Day	Bbls. Gain	Percent Gain Yearly	Percent Gain over 1948
1948	43,852,000	119,100	base year, 100		
1949	53,151,000	145,600	39,569,000	21.9	121
1950	91,325,000	250,800	38,174,000	71.8	208
1951	115,271,000	315,800	19,446,000	26.2	263
1952	127,204,000	348,500	11,933,000	10.4	290
1953	150,935,000	413,240	23,731,000	18.6	344
1954	162,115,000	444,150	11,180,000	7.4	370

TABLE II

Percentage of Production Refined in Venezuela

Year	Barrels Produced	Barrels Refined	Percent Refined
1948	490,770,000	43,582,000	8.8
1949	483,210,000	53,151,000	11.0
1950	547,470,000	91,325,000	16.6
1951	623,070,000	115,271,000	18.5
1952	660,490,000	127,204,000	19.2
1953	644,586,000	150,935,000	23.4
1954	691,790,000	162,115,000	23.4

TABLE III

Production Growth (compare Table I)

Year	Barrels Produced	Change, in Barrels	Percent Change Yearly	Percent Change Over 1948
1948	490,770,000	base year, 100		
1949	483,210,000	—7,560,000	—3.5	96
1950	547,470,000	56,700,000	13.3	111
1951	623,070,000	132,300,000	13.8	126
1952	660,490,000	169,720,000	7.0	134
1953	644,586,000	—15,904,000	—2.4	131
1954	691,790,000	47,204,000	7.3	141

TABLE IV

Major Refineries & Throughput

Company	Location	Daily Rate, barrels Year, 1954	%	Feb. 1955	%
Shell	Punta Cardon	169,300	38.2	180,000	35.6
Shell	San Lorenzo	45,600	10.3	40,000	7.9
Creole	Amuay Bay	86,200	19.5	138,600	27.4
Creole	Caripito	60,000	13.5	71,400	14.2
Vengref[1]	Puerto la Cruz	56,800	12.8	48,000	9.5
Sinclair	Puerto la Cruz	15,100	3.4	10,000	2.0
Texas	Tucupito	8,200	1.9	15,000	3.0
Phillips	San Roque	1,800	0.4	2,000	0.4
		443,000	100.0	505,000	100.0

[1] Owned by Gulf & Texas

TABLE V

Products Derived in Venezuelan Refineries, 1953-54

Product	Barrels 1954	% 1954	% 1953
Fuel oil	91,690,000	56.6	56.5
Gasoline & naphtha	22,222,000	13.7	15.0
Diesel oil	22,128,000	13.6	15.5
Gas-oil	10,173,000	6.3	4.0
Kerosine	5,578,000	3.4	3.0
Lubricants	1,001,000	0.6	1.0
Asphalt	644,000	0.5	0.5
Others	9,099,000	5.6	5.0
Losses	—420,000	—0.3	—0.5
	162,115,000	100.0	100.0

TABLE VI

Crude & Products Exports Compared

Year	Total Exports	Barrels Exported Crude	Refined	Approx. Percent Crude	Refined
1949	460,013,000	422,828,000	37,185,000	92	8
1950	526,318,000	452,348,000	73,970,000	86	14
1951	589,728,000	502,646,000	87,082,000	85	15
1952	626,798,000	531,904,000	94,884,000	85	15
1953	607,466,000	489,567,000	117,809,000	81	19
1954	654,884,000	528,634,000	126,250,000	81	19

TABLE VII

Production and Exports Compared

Year	Production	Total Exports, Crude and Refined	Percent Exported
1948	490,770,000	470,320,000	95.8
1949	483,210,000	460,013,000	95.2
1950	547,470,000	526,318,000	96.1
1951	623,070,000	589,728,000	94.7
1952	660,490,000	626,798,000	95.0
1953	644,586,000	607,466,000	94.1
1954	691,790,000	654,884,000	94.7

tion went up about one-half of one percent. Miscellaneous products, including a long list from jet aviation fuel through liquid propanes to weed-killer, rose fractionally.

Gasoline and naphtha production declined somewhat in 1954, as did diesel oil and lubricant production. Asphalt remained steady at one half of one percent. This product is widely used in road construction in Venezuela, being transported to the jobsite in heated trucks.

The proportions of crude and derivatives shipped out of Venezuela in 1954 remained constant when compared with 1953, as Table VI shows. The 654,884,000 barrels exported were divided 81 percent crude and 19 percent refined products. In 1948 the proportion was 92 to 8.

Major world markets for Venezuelan crude remained about the same last year as in 1953, with the only notable change a two percent gain in European consumption (Table IX). As for refined products, the United States took an additional one percent of output, South America took 1.5 percent less, and miscellaneous small markets accounted for an increase of two percent.

Table VIII shows in a general way what became of Venezuela's exports in 1954, as does Table IX. The ultimate destination of the 40 to 50 percent of Venezuelan production that goes to the Dutch West Indies for further refining and distribution is unknown. There it meets several hundred millions of barrels of crude per year coming from other sources and loses its identity.

Venezuela's internal consumption of domestically refined oil has more than doubled since 1949, from 43,800 b/d to 98,300 b/d. However, the output of refined products has so far outstripped demand that, while 30 percent of derivatives was consumed locally in 1949, the percentage had dropped to 22.1 in 1954, leaving some 78 percent available for export (Table X).

For its petrochemical project, the government has acquired 5,000 acres of land at Moron, near Puerto Cabello. The plant is scheduled to be completed by mid-1957 and in full operation by 1960. The raw materials being principally natural gas and

TABLE VIII

Major World Markets for Total Venezuelan Exports, 1954
(including crude and refined)

	Barrels	%
Aruba-Curaçao[1]	284,599,757	43.46
North America	234,706,252	35.84
Europe	57,347,175	8.76
South America	42,738,562	6.52
West Indies[2]	22,128,573	3.38
Asia	8,124,737	1.24
Africa	3,501,682	0.54
Oceania	1,017,482	0.15
Central America	371,594	0.06
Whalers	348,574	0.05
	654,884,388	100.0

[1] Refinery sites
[2] Except Aruba-Curaçao

oil, the industry is keenly interested in this project.

Credit for the conception of the idea is given to President Marcos Perez Jimenez, whose administration since late 1948 has made astounding strides in the material progress of the country.

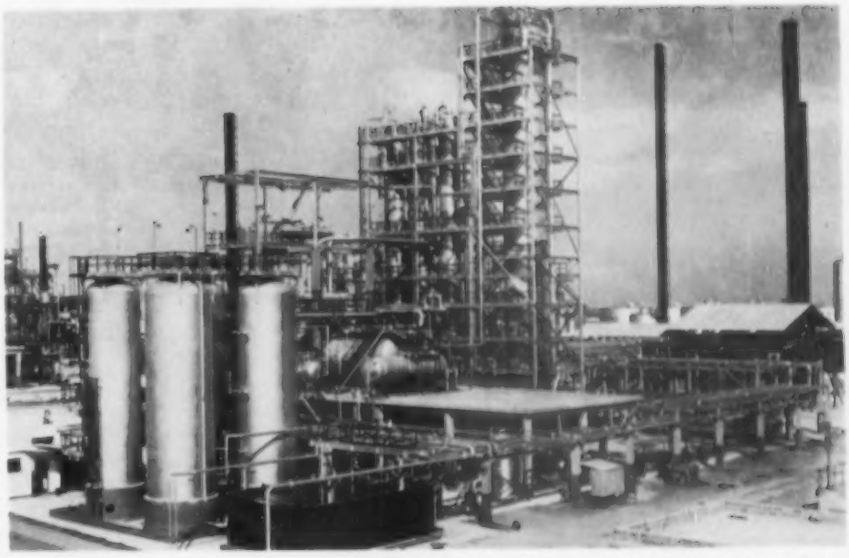
The petrochemical plan unites several often-expressed aspirations of the government: industrialization; "sowing the petroleum"; rational utilization of natural gas produced with the oil, a large proportion of which still must be flared, though its use in pressure-maintenance and reinjection projects is increasing year by year; a boost to agriculture through the local production of fertilizers; greater self-sufficiency in food crops; and development of mineral resources, such as salt and sulfur.

The program is divided into logical phases of priority. In the first phase, emphasis will be placed on nitrogen derivatives, and the fabrication of such fundamentals as ammonia, sulfuric and nitric acids, from which many fertilizers can be made, as well as explosives for civilian and military uses. The second phase will be devoted to the production of chlorine and caustic soda, the third to the derivatives of acetylene, and the fourth to ethylene, butylene and other oil fractions, looking toward the manufacture of plastics, synthetic rubber, detergents, colorants, drugs, and the like.

The various units to be constructed and their daily capacity are: one for anhydrous ammonia, 100 tons; one for 53 percent nitric acid, 185 tons; 98 percent nitric acid, 30 tons; nitrate of ammonia, 20.5 percent N, 150 tons; nitrate of ammonia, 10 tons; sulfuric acid, 98 percent by weight, 200 tons; sulfate of ammonia, 20.5 percent N, 240 tons; superphosphate, 300 tons; granulated superphosphate, 300 tons; and urea, 50 tons.

Plans call for an initial yearly production of 150,000 tons of fertilizers, 5,000 tons of chlorine, 5,600 tons of caustic soda, and 5,000 tons of dynamite. Last year, 18,000 tons of fertilizers were imported into Venezuela. However, fertilizers from the new plant are expected to sell for half the price of the imported product, and consumption is expected to increase accordingly. Government-sponsored farm projects alone will use one-third of the contemplated production.

The Moron site was chosen for its strategic position. It is close to a port, on the hub of main highways, on the new railroad line now being laid out from Puerto Cabello to Barquisimeto, and accessible to oil and natural gas sources. With an oil terminal to be established in the same vicinity, the chances are that the area will become an important industrial center.



Furfural extraction plant at Shell's Punta Cardon refinery.

TABLE IX

World Markets for Venezuelan Crude & Derivatives

	Percent of Crude Exports				Percent of Refined Exports			
	1954	1953	1952	1951	1954	1953	1952	1951
Aruba-Curaçao[1]	50.05	51.71	55.28	59.24	15.86	15.12	14.14	15.53
United States	24.44	24.49	23.18	21.43	34.27	33.22	30.52	28.76
Canada	10.98	11.68	9.61	6.98	2.37	2.65	2.80	3.53
Europe	7.12	5.00	5.05	4.34	15.59	15.97	20.20	25.20
South America	3.65	3.61	3.05	2.27	18.56	21.04	23.23	19.21
Africa	...	...	...	...	2.77	3.76	2.86	2.47
Brit. West Indies	2.98	3.04	2.93	2.84	2.42	2.12	3.38	3.65
Others	0.78	0.47	0.90	0.90	8.16	6.12	2.87	1.65
	100.	100.	100.	100.	100.	100.	100.	100.

[1] Refinery sites

TABLE X

Internal Consumption of Domestically Refined Products

Year	Barrels	b/d Avg.	% of Total Refined Prod.
1949	15,966,000	43,800	30.0
1950	19,355,000	53,000	21.5
1951	28,189,000	77,200	24.5
1952	22,320,000	61,200	17.3
1953	33,126,000	90,800	21.9
1954	35,865,000	98,300	22.1

Panoramic view of Shell's Punta Cardon refinery.

A year ago Brazil had an oil refining capacity of 11,950 barrels daily. Today this has been increased more than six-fold to 86,950 b/d. Capacity now is adequate to take care of half of the national requirements for petroleum products as compared with less than ten percent a year ago. The 75,000-barrel increase in capacity is centered in three plants, the first of which, a 10,000-barrel plant, was completed last December by Refinaria de Petroleo de Manguinhos. The two latest and largest additions to Brazil's refining industry are described in the two accompanying articles.

BRAZIL—

WORLD'S LARGEST TCC UNIT INSTALLED AT CAPUAVA REFINERY

By J. H. Arnold*

Consulting engineer John H. Arnold supervised the mechanical engineering design and initial operations of the world's largest TCC cracking unit at Capuava, Brazil, discussed in the accompanying article. Mr. Arnold was one of the organizers of Hydrocarbon Research, Inc., in 1943 and was vice president and a director when he entered private consulting work last September. He began his refinery engineering work in 1932 after earning his master's degree in chemical engineering from M.I.T. His first job was as a group leader in research and development for The M. W. Kellogg Co. Kellogg assigned Mr. Arnold to the Kellex Corp. during World War II as director of research and development with a staff of 300. His work included direction of the design of special equipment for the Oak Ridge gaseous diffusion plant. Preparation of operating manuals and preliminary equipment testing was also under his direction.

FOURTEEN MILES to the north of Sao Paulo, on a terraced hillside high on the sierra at Capuava, lies the newest of Brazil's refineries. Organized and wholly owned by private Brazilian interests under the name of Refinaria e Exploracao do Petroleo "UNIAO" S.A. and operating under concession from the Brazilian governnment, this refinery is another important advance in the industrialization of Brazil. By producing gasoline 12 months after the first foundation was poured, the refinery beat only by weeks the January 1, 1955 operating deadline recently established by the Petrobras law as it applies to privately owned refineries.

The Capuava refinery, designed and constructed by Hydrocarbon Research, Inc. of New York, embodies the latest American refining techniques, including the largest Thermofor catalytic cracking unit ever built and a large phosphoric acid catalytic polymerization unit. The Thermofor unit is operated under license of the Socony Mobil Oil Co., Inc. and the catalytic polymerization plant under license of the California Research Corp. The Capuava refinery is a complete refinery in the sense that it has all the auxiliary facilities necessary to operate and maintain the refinery, such as crude and product handling and storage facilities, laboratories, shops, steam boilers, water systems, and generators adequate to supply the entire electrical power load.

The refinery has a crude capacity in excess of 20,000 b/d and it can handle a wide variety of stocks, including crude oils of high sulfur content and high salt content. Thus it can handle efficiently most of the crude oils available on the world market. Also, the refinery will be able to handle almost any indigenous crude oil which may be produced in commercial quantities in the future.

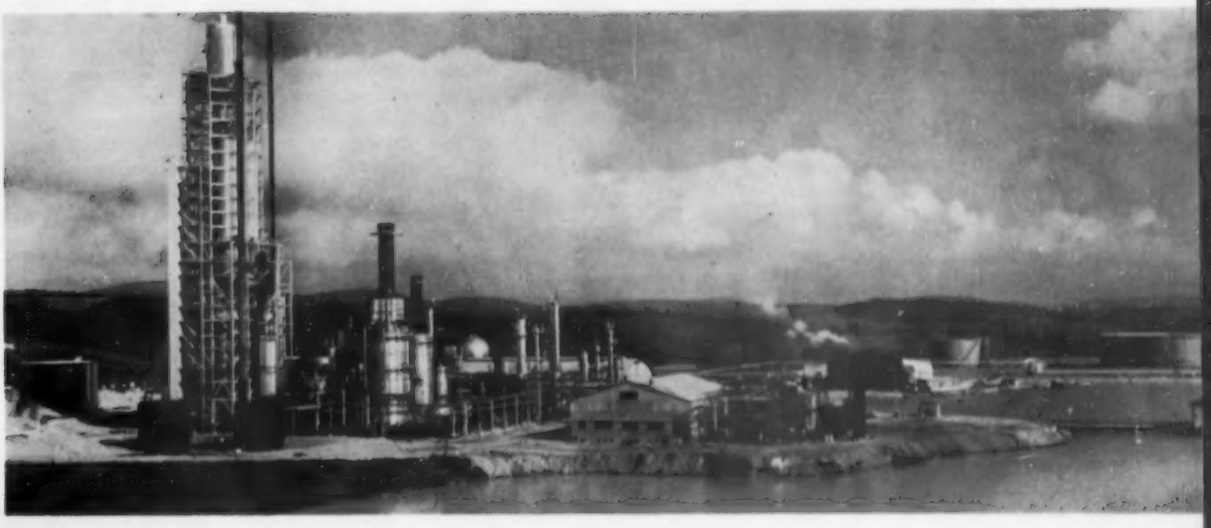
The refinery has successfully passed its guaranteed performance tests and is presently operating at full capacity producing a single pool gasoline, a No. 4 fuel oil, a No. 6 fuel oil, propane and butane. From an average Kuwait crude oil the refinery will produce approximately 12,000 b/d of gasoline, 6,000 b/d of fuel oils and 60,000 gallons per day of propane and butane. The gasoline will have an octane rating of about 70 clear which can be raised to 82 or higher by the addition of tetraethyl lead. The properties of all products are typical of those sold in the United States and they meet current ASTM and NGAA specifications.

The refinery was designed with provisions for the integration of additional equipment to expand the number of products to include: 90 octane premium motor gasoline, solvent naphthas, kerosine and diesel oil. Also, the existence of the operating refinery is the basis for future expansion into the production of other more specialized petroleum products such as aviation gasoline, lubricating oils, greases, waxes and asphalts and petrochemicals such as benzol, tetramer, carbon black, sulfur, ammonia, methanol and higher alcohols, acetylene and vinyl compounds.

The crude oil is received by tanker at the port of Santos 30 miles to the southeast. It is unloaded into a pipe line which conducts it to either of two 150,000-barrel

* *Consultant, Hydrocarbon Research, Inc.*

Fig. 1: General view of Capuava refinery.



storage tanks situated at the foot of the escarpment. From these two storage tanks it is pumped through a second pipe line over the escarpment and on to the refinery site. There are four 150,000-barrel storage tanks at the refinery site, set on a terrace about 20 feet above the refinery units. The crude flows from the refinery storage tanks to the refining units by gravity. The two crude storage tanks at the foot of the escarpment and the four tanks at the refinery together hold a 45-day supply of crude oil.

The gasoline, fuel oils, propane and butane products are loaded into railroad tank cars and automotive tank trucks for transportation to the Sao Paulo area and elsewhere. Provision has also been made to discharge gasoline and fuel oils into the product pipe lines now contemplated between Capuava and the bulk terminal at Utinga, a suburb of Sao Paulo.

Figure 1 is a view of the refinery looking down the hill to the southeast. The edge of the water reservoir can be seen in the foreground. The tall structure at the left is the catalytic cracking unit, and the other processing equipment is adjacent to it. The steam and electrical generating facilities are seen across the road to the left of the process equipment, and to the rear are the cooling tower and the product storage tanks. Higher on the hill to the left and out of range of the camera are the crude storage tanks. The elevation of the crude oil storage tank farm is about 100 feet above the elevation at the administration area and the distance by road from the administration area to the crude tanks is one mile.

The refinery units are arranged for the most part in a single processing line with no intermediate storage and no blending tanks and with the minimum of run down and slop tanks. If the crude contains salt, the salt is first removed in a conventional electrostatic precipitation unit. The salt-free crude is then preheated in a furnace and topped of gasoline and light gas oil in the upper section of the main fractionating tower.

The crude bottoms are further heated in a second furnace and flashed in two stages, first with steam at essentially atmospheric pressure and then under a vacuum of 21 inches of mercury. The vacuum bottoms flow directly to the No. 6 fuel run-down tank. The overhead fractions from both flash drums flow to the catalytic cracking unit. The effluent from the catalytic cracking unit flows into the lower section of the same main fractionating column used to top the crude.

Combined gas and gasoline fractions from crude topping and cracking leave the top of the main fractionator and are separated in the fractionator overhead drum. Light fuel oil is withdrawn as a side stream from the upper section of the mail fractionator into a stream stripper and the bulk of the stripped product flows directly to the No. 4 fuel oil run-down tanks. The remainder is used to cut the No. 6 fuel oil to specification viscosity as it flows to its run-down tanks. The cracked gas oil is withdrawn as a side stream from the lower section of the main fractionator and is mixed with the topped crude as it flows to the preheater furnace and flash drums and thence back to the cracking unit. The bottoms from the fractionator flow to settling tanks to remove any catalyst fines and then to No. 6 fuel oil run-down tanks.

Gas from the separator drum is compressed to approximately 300 psig in two stages: the first stage is a centrifugal compressor and the second stage a reciprocating compressor. The gasoline from the separator drum is pumped also to 300 psig. The two streams flow to the recovery unit where they are separated into a light fuel gas, a propane-butane fraction, and a debutanized gasoline. The debutanized gasoline is caustic washed, copper sweetened and inhibited and then flows to its run-down tanks. The propane and butane fraction is amine washed to remove sulfur and then charged to the catalytic polymerization unit. The effluent from the catalytic polymerization is depropanized. Part of the propane is recycled to the polymerization reactors to limit the olefin concentration of the feed and the net propane product is dehydrated and run directly to storage. The depropanized effluent is charged to a debutanizer. The butane overhead flows directly to the butane run-down sphere and the debutanized polymer gasoline flows to its run-down tank, being inhibited on the way.

The single pool gasoline is a blend of the virgin-cracked gasoline from the copper sweetening unit, the polymer gasoline, butane, inhibitor, lead tetraethyl and dye. As described previously, the virgin-cracked gasoline blend and the polymer gasoline are inhibited on the way to the run-down tanks. The remainder of the blending is done in a continuous blending unit. The rates of flow to the two gasoline stocks and

the butane, each from its respective run-down tanks, and the rate of flow of lead tetraethyl and dye from their weigh tanks are regulated by proportioning pumps and other flow control devices. All are mixed in the transfer piping as they flow from the run-down tanks and weigh tanks and the final blend flows directly to the gasoline storage tanks and from the storage tanks to the loading racks.

The blending pumps also serve as the only gasoline transfer pumps in the refinery. They are so manifolded that they can also pump from the run-down tanks back to the main fractionator or back to the crude tanks. The gasoline and fuel oil product storage tanks are situated high on the hill at the same level as the refinery and these products flow to the loading area at the foot of the hill by gravity. The propane and butane products are stored at the foot of the hill and are loaded under their own pressure.

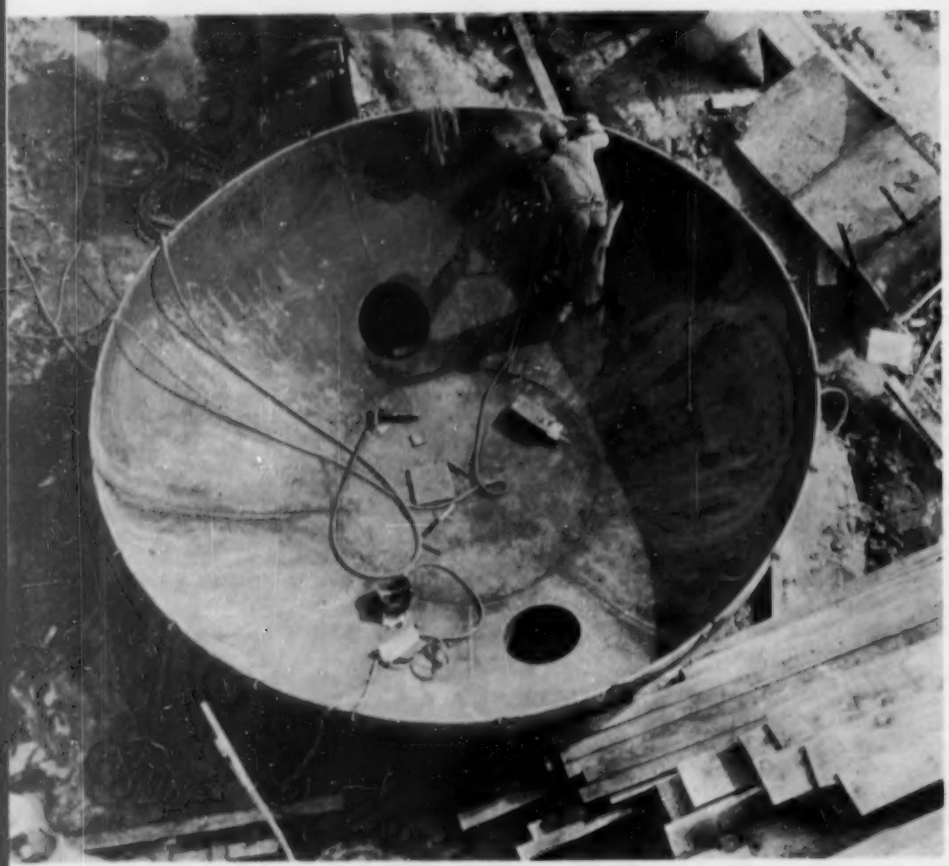
The catalytic cracking unit is the first type 120 Thermofor unit to be erected. It has a coke burning capacity of 12,500 pounds per hour, which is 80 percent greater than the next largest size, the type 70. The cracking unit has a single reactor 18 feet in diameter and 50 feet tall and a single regenerator 35 feet in diameter and 50 feet tall. The reactor has a design capacity in excess of 20,000 b/d of virgin and cracked gas oil. The unit is currently operating on synthetic catalyst from Germany and the catalyst loss is now running less than 0.4 lbs./bbl. of gas oil feed. The unit incorporates all the automatic and protective devices of the smaller Thermofor units. Other large pieces of equipment include the main preheater furnace and the main fractionator. The furnace has vertical tubes 70 feet long and the average tube circle is 22 feet. The fractionator is 17 feet in diameter and 72 feet tall.

Hydrocarbon Research supervised the erection of all facilities at the refinery site with the cooperation of UNIAO's able engineering staff. The detailed construction work was performed by local Brazilian contractors with the exception of the erection of the TCC structure and the main fractionating tower, which was done by Chicago Bridge and Iron Co. and its Brazilian affiliate. To supervise the construction, Hydrocarbon Research, Inc. sent to Brazil a construction superintendent with a staff of approximately 30 American engineers and other personnel experienced in the erection of petroleum refineries. At the outset of the work, this group established training schools for all trades and the results were very rewarding. For example, over one hundred Brazilians with little or no previous experience in welding high pressure piping were able to pass qualifying tests conducted in strict accordance with American procedure and the fact that the plant was erected in one year attests to the high caliber of their work and the work of all trades.

Essentially all of the refinery equipment and the major construction tools were imported from the United States. They were shipped by boat to the port of Santos and from there they were transported to the refinery site over a single track railroad. In order to complete the erection within the time schedule, equipment was prefabricated to the maximum extent practicable before shipment to the site. Coordination of the transshipment of material from the port with the day-to-day requirements of the various construction crews at the re-

Pre-assembled hot catalyst tank ring for TCC unit.

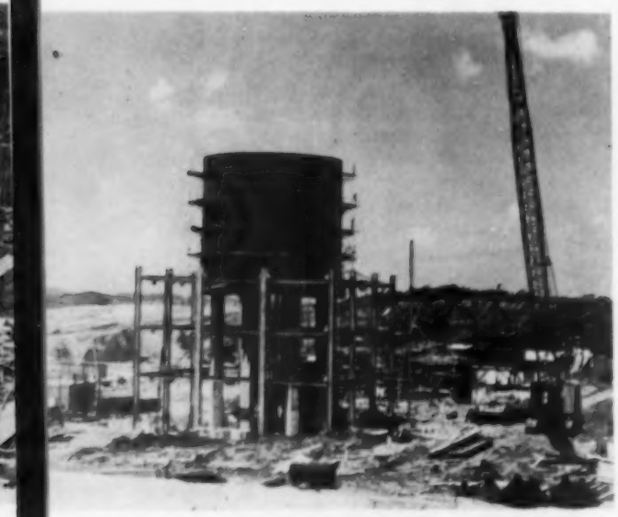
Pre-assembly of fractionator head for TTC unit. All construction photographs with this article are reproduced through the courtesy of Chicago Bridge & Iron Co., erector of the TCC structure and the main fractionating tower.



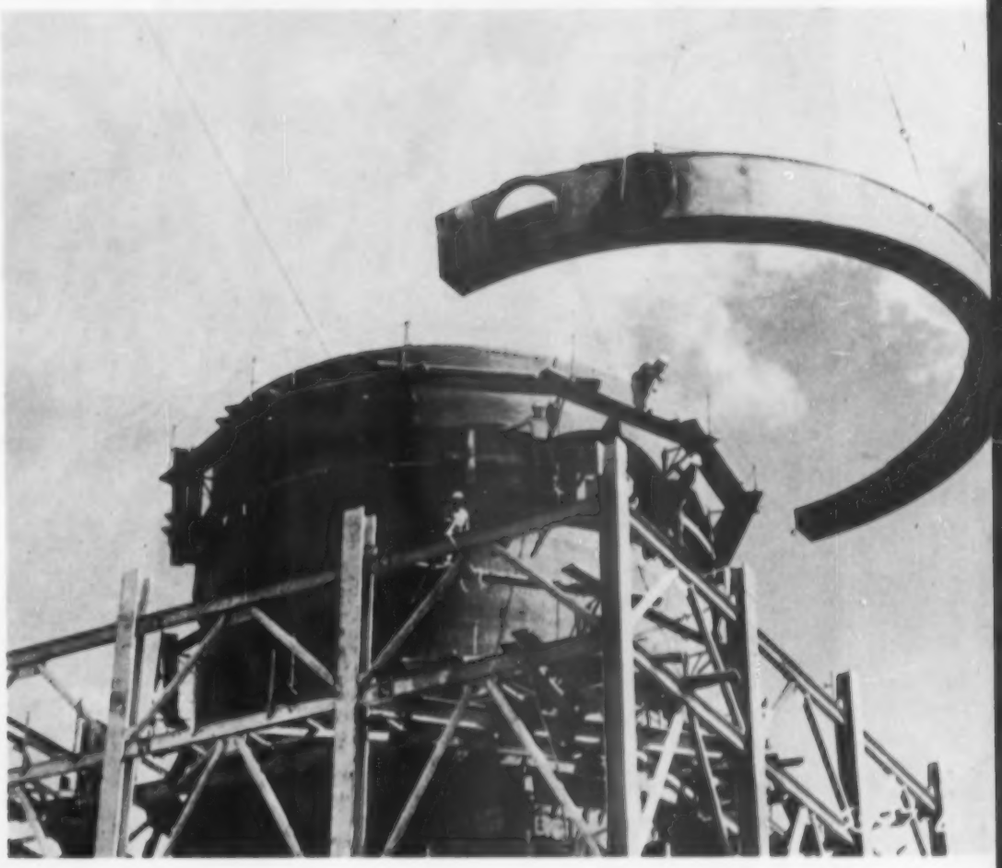
finery prevented the railroad from ever becoming a serious bottleneck. Common building materials, a part of the electrical power distribution materials and equipment and other miscellaneous materials were procured in Brazil.

The Thermofor reactor and regenerator and the main fractionator were assembled at the refinery site. All field welded seams were gamma rayed, using a radium pill as the radiation source. A program of testing of piping welds was also carried on using the same technique. At the peak of the work about 1,400 Brazilian engineers, tradesmen and laborers were engaged in the various construction activities on a day and night shift basis.

Hydrocarbon Research, at the request of UNIAO, is furnishing management services and is assuming full executive authority and responsibility for all technical operations of the refinery while UNIAO is exercising full authority and responsibility for all administrative activities. To render this service, Hydrocarbon Research sent to Brazil a veteran refinery superintendent and a staff of approximately 20 engineers, operators and personnel experienced in petroleum refining practices. The administrative activities and the actual operation of the facilities is being carried on by a full compliment of Brazilian personnel, approximately 350 individuals in all, recruited by UNIAO. Few have had any previous experience in petroleum refining or related industries, but the majority have proved to have the necessary intelligence and aptitude to learn quickly.



Starting erection of the TCC unit.



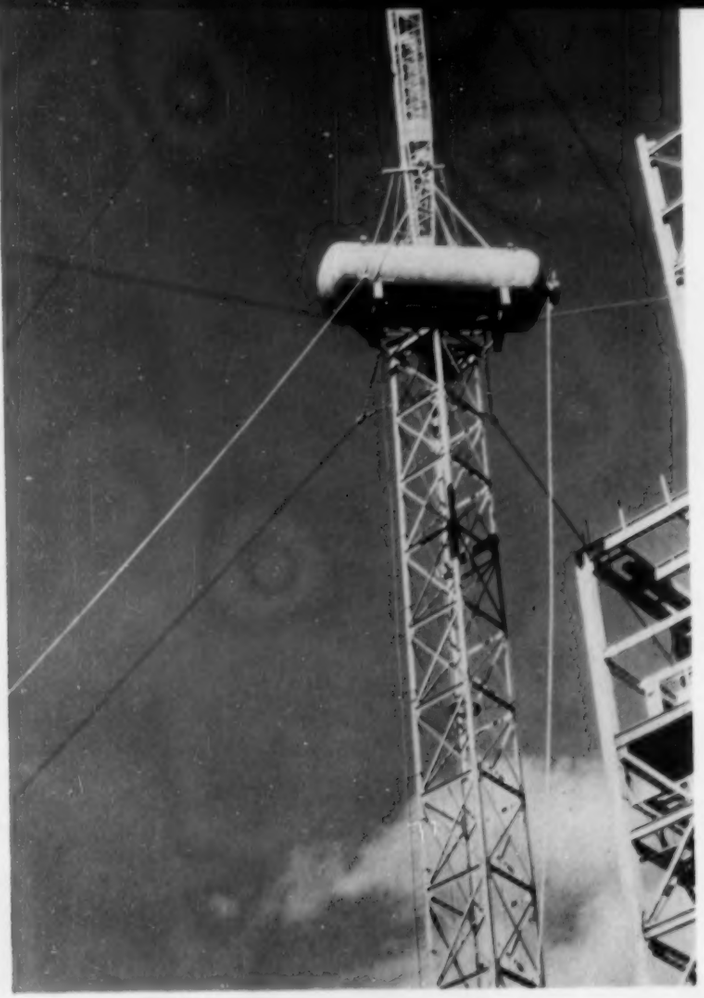
Raising air duct for TCC kiln.

In preparation for the initial operation of the plant, Hydrocarbon Research, in co-operation with UNIAO, organized a program to train the Brazilian personnel in the art of operating a petroleum refinery. Senior members of the Brazilian technical and operating staffs underwent several months of intensive training in the United States, including extended visits to major refineries, In addition, the entire Brazilian technical and operating staffs were trained at the refinery site for approximately three months prior to the operation of the plant.

After an initial production period, UNIAO will assume executive authority and responsibility for all technical operations as well as for all other activities. The Hydrocarbon Research staff will then remain at the refinery in an advisory capacity for one year. Thereafter it is anticipated that the Brazilian personnel will be able to run the refinery without advice on day-to-day operations. Hydrocarbon Research, Inc. will continue to serve as consultant to UNIAO, monitoring the operation of the refinery and keeping the management abreast of the latest developments in petroleum refining and petrochemicals.

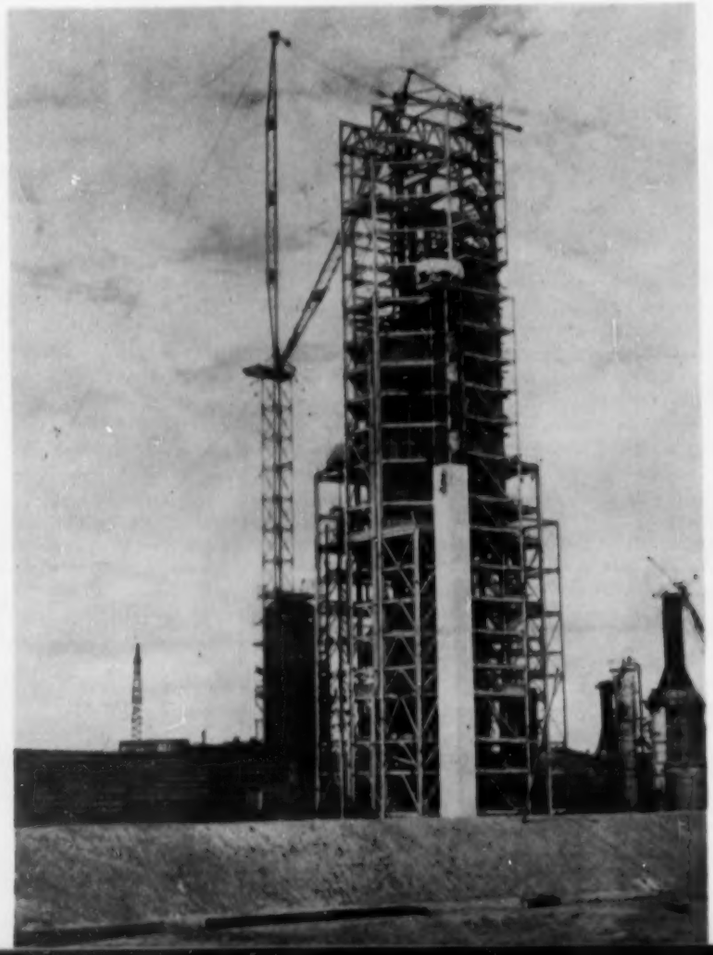
It is a compliment to the ability of the Brazilian personnel that the refinery has been brought on stream with no more than the usual difficulties incident to starting any completely new industrial establishment despite a language barrier and an almost complete lack of prior experience.

There was a serious water supply and demand problem which had to be solved before a refinery could be erected at Capuava. Despite the fact that the Tamandautei River flows across the property, UNIAO is enabled by local authorities to withdraw water only when the flow exceeds 3,500 gallons per minute, and rarely does the flow exceed this rate except at intermittent periods during the rainy months of December through March. It



Raising 23-ton steam drum with a 25-ton capacity derrick.

Installing a jib on a 25-ton capacity derrick.



was therefore imperative to provide means for capturing the water when available and storing it until needed. To store the water, a reservoir with a working capacity of 150 million gallons was created by closing the open end of a natural amphitheater formed by a ridge close to the top of the hill. This operation required nearly one and one half million cubic yards of dirt, most of which was cut from the hillside in the grading of the site for the refining units.

Since it was not practical to create more reservoir capacity and since it was necessary to design the refinery to operate with the equivalent of one reservoir full of water from the end of one rainy season to the beginning of the next, the water demand for the refinery was set at 400 gpm, hardly more than half the water consumption of the average 20,000 b/d refinery equipped with cooling towers or spray ponds. One major design step taken to reduce the demand for water to 400 gpm was to substitute ten air fan coolers having a combined duty of approximately 130 million Btu/hr for the more conventional tube and shell water coolers. A second major step was to limit the steam consumption to essentially the by-product steam necessarily generated in the operation of the catalytic cracking unit, and to use diesel-driven electric generators to supply the balance of the power. In many instances where steam turbine drives were installed to run on by-product steam, spare units with motor drives were provided so that it is possible to balance the steam consumed and the by-product steam produced over a relatively wide range. The refinery's two 75,000 lb./hr. boilers are used primarily to start up the refinery. During normal operations only one boiler is on line and its output is limited to that necessary to keep it warm so that it will always be available for sudden demands during operating emergencies. Other less important steps taken to save water include the capture and retreating of boiler blowdown water and process steam condensate.

To capture the water during the times when it is available, a pumping station was erected about 300 feet back from the river and a forebay having a capacity of approximately one million gallons was dredged between the river and the pumping station. The river and the entrance to the forebay are both dammed and a weir is cut into the river dam sufficiently below the level of the top of the forebay dam so that no water spills into the forebay until the flow down the river reaches 3,500 gpm. When water spills into the forebay, the rising level automatically starts the first of the four pumps at the pumping station, and if the level continues to rise, each of the other pumps, in turn, starts automatically. All four pumps can draw water at the rate of 12,000 gpm. It is not anticipated that all four pumps will often run simultaneously, but if the water were available they could pump a year's supply in about 12 days.

BRAZIL—

45,000 b/d refinery at Cubatao

By P. C. Keith and E. T. Layng

P. C. KEITH, president and chairman of Hydrocarbon Research, Inc., worked for short periods with The Texas Company, Universal Oil Products Company, and for the Kansas City Testing Laboratories early in his career. At the Kansas City Testing Laboratories, he was associated with the Cross brothers, pioneers in thermal cracking of petroleum. For many years Mr. Keith was vice president of the M. W. Kellogg Company, where he was in charge of all engineering, processing and research work. During the period immediately preceding this country's entry into World War II, Mr. Keith was active in the design and engineering of plants for the production of aviation gasoline, toluene, butadiene, synthetic rubber, anhydrous ammonia, magnesium metal, and small mobile plants for the separation of oxygen from air. He also spent several months each year in Germany, working with German chemists and engineers to develop and improve the Fischer process for producing synthetic gasoline. At the outbreak of World War II, Mr. Keith was appointed to the newly created planning board of the S-1 section of the Office of Scientific Research and Development, the forerunner of the Manhattan District atomic bomb project. During the early months of 1942, he directed the engineering research and development of the diffusion process under the sponsorship of the O.S.R.D. Later, as vice president and technical director of the Kellex Corporation, he was responsible for all research and development, process design, engineering, procurement of materials and supervision of plant construction for the Oak Ridge gas diffusion plant. For his part in the development of the atomic bomb, Mr. Keith was awarded the Medal of Merit, the highest honor granted to civilians by the United States Government.

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DR. E. T. LAYNG is vice president in charge of technical administration and commercial business, including patents and contracts, for Hydrocarbon Research. Prior to joining Hydrocarbon in 1943, he was associate director of research of the M. W. Kellogg Company, where he was responsible for the development of the "Polyco" catalytic polymerization process and the recovery of toluene from catalytic reformate. Dr. Layng also supervised the operations of Kellogg's catalyst manufacturing plants. During the war, he served on many government technical and advisory committees.

THE NEW government-controlled refinery located at Cubatao, just ten miles northwest of the port of Santos, Brazil, commenced initial operations in February of 1955. Since March, the topping unit has run steadily at or above design capacity and the visbreaker has been on stream since May. When all of the processing units are in operation later this summer, this refinery will supply a substantial part of Brazil's current demand for motor gasoline and fuel oils. It will also produce a significant quantity of aviation gasoline. The refinery was designed and constructed under the direction of Petroleo Brasileiro, S.A. (Petrobras) and its predecessor, Comissao da Refinaria de Petroleo de Cubatao.

The refinery has a nominal capacity of 45,000 barrels of crude oil per day and is able to process economically almost any type of crude oil, including crude oils of high sulfur content and high salt content. The basic design of the refinery was predicated upon the processing of medium gravity crude oils from the Middle East or Venezuela, but considerable flexibility was incorporated into the design with a view toward the day when there may be sufficient Brazilian crude to service this refinery.

The refinery, as presently erected, will produce liquefied propane and butane, motor gasoline, kerosine, diesel oil and fuel oil. From an average Venezuela crude oil, the refinery will produce 21,500 b/d of motor gasoline having an octane number of 75-76 before the addition of tetraethyl lead, 4,500 barrels of kerosine, 4,500 barrels of diesel oil, 12,800 barrels of heavy fuel oil, and 3,000 barrels of liquefied propane and butane. All products will meet the applicable specifications of the American Society of Testing Materials and the Natural Gasoline Association of America.

The refinery is also presently equipped to separate an isopentane fraction, a light naphtha fraction free of normal pentane, and a di-isobutylene fraction. Designs for facilities to hydrogenate the di-isobutylene to iso-octane are already completed, and when these facilities are installed the refinery will be capable of producing well over 2,500 b/d of 91/98 aviation gasoline or, alternatively, higher grade aviation gasolines up to 1,000 barrels of 115/145 grade. Facilities are also being installed or planned for the manufacture of synthetic ammonia from the refinery gas, for the production of 3,000 b/d of road asphalt and for the separation and recovery of ethylene. The production of other refined petroleum products and petrochemicals is under consideration.

Crude oil presently arrives at Santos by tanker and facilities are available to unload the tankers directly into lines leading to the crude storage tanks at the refinery. The gasoline and fuel oils are moved from the refinery through three product lines running up over the escarpment and on to a bulk loading station in the vicinity of Sao Paulo or, alternatively, back to the port for tanker shipments from Santos. The liquefied propane and butane can be loaded into either tank trucks or railroad tank cars.

Process designs and specifications for the Cubatao refinery were prepared by Hydrocarbon Research, Inc. of New York. They embody the latest American techniques and practices for this type of refinery. Since the bulk of the equipment, excepting instruments and certain other highly specialized apparatus, was fabricated in Western Europe, the detailed engineering of the refinery was executed in Duesseldorf, Germany, by Hydrocarbon Mineraloel, G.m.b.H., the German affiliate of Hydrocarbon Research, Inc. Mechanical engineering designs and specifications were prepared strictly in accordance with the standards of the American Petroleum Institute, but the engineering was detailed to utilize to the maximum extent materials and equipment in Europe and to accommodate the designs of special equipment to the experience and shop facilities of European fabricators. A major portion of the process equipment was furnished by the French firms of Fives-Lille and Schneider.

Night view of Brazil's new 45,000 b/d refinery at Cubatao.

Procurement activities, including purchasing, inspection and expediting, were centralized in Paris under the direction of a purchasing commission established there for this project by Comissao da Refinaria de Petroleo de Cubatao. In this work they were assisted by Hydrocarbon Engineering, S.a.r.l., the French affiliate of Hydrocarbon Research, Inc., as well as the German affiliate. For procurement in the United States a similar purchasing commission was created.

The construction of the refinery at Cubatao was accomplished by Petrobras and its predecessor, acting as general contractor and coordinator, and Hydrocarbon Research, Inc., serving in a consulting and supervisory capacity as architect-engineer. The bulk of the actual erection work was carried out by local Brazilian contractors, but the erection of the process units was entrusted to Arthur G. McKee and Co. of Cleveland, who also served as consultant on erection practices and details. The McKee Co. furnished about 40 individuals skilled in the various aspects of construction and also provided the larger construction tools. In order to reduce to a minimum the steel which had to be imported, equipment supports which would normally be fabricated of structural steel shapes were made of reinforced concrete. The large towers and furnaces, as well as smaller equipment and even process and utility piping, are supported entirely by reinforced concrete structures.

In preparation for the start up of the refinery units, Hydrocarbon Research engineers, in collaboration with the Petrobras engineers, conducted training schools in the art of petroleum refining at the plant site. Hydrocarbon Research, Inc. is presently supervising the start up of refining facilities and also is furnishing management assistance in the operation and maintenance of the refinery. To perform these services Hydrocarbon Research has in residence at this refinery an experienced refinery supervisor and a staff of more than 50 senior engineers, operators, and other personnel experienced in petroleum refining practices. Petrobras ultimately intends to assume complete responsibility for all phases of the refinery operations.

The crude distillation unit has already completely fulfilled its guarantee tests and it is expected that other units will follow in quick succession with the complete refinery operating at capacity before the end of summer.

Description of Process Units: The refinery is comprised of single, large processing units with a minimum of intermediate storage. There are seven principal processing units. In addition to the crude unit, they are: (1) the viscosity breaker, (2) the combination naphtha reformer and gas oil cracker, (3) the light ends separation and recovery unit, (4) the catalytic polymerization unit, (5) the treating units and (6) the gasoline blending unit.

The crude distillation unit consists of a crude heater, a crude tower with light and heavy gas oil strippers, a naphtha stabilizer, a naphtha splitter and an isopentane separator. The crude heater has two preheat sections and a single radiant section. Each section is an individual vertical tube furnace. The active length of the tubes is 45 feet and the tube circles 14-20 feet. The crude tower is 12½ feet in diameter and 67 feet tall and the isopentane separator is 9 feet in diameter and 110 feet tall. The other towers are smaller. The crude tower and the stabilizer operate at substantially atmospheric pressure and the other towers at slightly higher pressures.

Crude passes from storage through the electrostatic desalter and on to the crude distillation unit. The salt-free crude is first split into naphtha, a light gas oil, a heavy gas oil and bottoms. The naphtha is then further split into a heavy naphtha, a light naphtha, normal pentane, isopentane and butanes. From an average Venezuelan crude the fractions will run 17,000 barrels per day of bottoms, 6,700 barrels of heavy gas oil, 7,000 barrels of light gas oil, 8,500 barrels of heavy naphtha, 4,300 barrels of light naphtha, 600 barrels of normal pentane, 300 barrels of isopentane and 600 barrels of butanes. The light and heavy gas oil fractions are withdrawn from their respective strippers as specification kerosine and diesel oil. The desired amounts are withdrawn as kerosine product and diesel oil product and the remainder is utilized as cracking stock.

The viscosity breaker consists of a furnace and a single combination tower. The furnace has two sections; a preheating section and a radiant section. Each section is an individual vertical tube furnace. Active length of the tubes is 55 feet and the diameter of the tube circles is 24 feet. The nominal combined heat release is 183 million Btu per hour. The combination tower is 12 feet in diameter and 70 feet tall. The furnace transfer line operates at 300 psi and 875°F. The tower operates at slightly above atmospheric pressure. The reduced crude flows directly from the base of the crude tower to the middle of the viscosity breaker tower. It is then pumped, admixed with heavy gas oil cycle stock, from an intermediate pan of the tower through the furnace. The effluent from the furnace is expended into the base of the tower. Fuel oil is withdrawn from the base of the tower. A heavy naphtha fraction and a light gas oil fraction are withdrawn as side streams from the tower without stripping and the light naphtha and gas pass overhead. The heavy gas oil, admixed with the reduced crude as previously described, is recycled to extinction. When processing an average Venezuelan crude, the fuel oil will run 9,600 barrels per day, the light gas oil 4,700 barrels, the heavy naphtha 1,400 barrels and the light naphtha 1,700 barrels.

The combination naphtha reformer consists of a naphtha reforming furnace, a light gas oil cracking furnace and a heavy gas oil cracking furnace, a combination tower and a fuel oil flash tower. Each furnace has two sections, a preheater and a soaker. Each section is an individual vertical tube furnace with the active length of the tubes 50 feet and the tube circles 15-20 feet. The combination tower is 13 feet in diameter and 85 feet tall. All three furnaces operate at 300 psi and the transfer line temperatures are: naphtha reformer, 1,025°F; light gas oil cracker, 1,010°F; and heavy gas oil cracker, 950°F. The combination towers operate at 250 psi and the fuel oil flash tower at essentially atmospheric pressure.

Heavy naphtha from the crude distillation unit and from the viscosity breaker flows directly to a small accumulator drum and is then pumped through the reformer furnace. Light gas oil and heavy gas oil from the crude distillation unit and light gas oil from the viscosity breaker flow directly to intermediate elevations of the combination tower and are pumped, admixed with recycle gas oil from appropriate pans of the tower, to the gas oil crackers. The effluent from all three furnaces is expended into the base of the tower.

Fuel oil is withdrawn from the bottom of the combination tower and flashed in the fuel oil flash tower. The cracked gas and gasoline leave the top of the combination tower. From an average Venezuelan crude oil from which 10 percent kerosine and 10 percent diesel oil are withdrawn as product, fuel oil will run 3,200 barrels per day and cracked gasoline 17,000 barrels.

The separation and recovery unit is essentially a low temperature distillation plant. Unlike the conventional recovery plant, it does not utilize an absorption oil. By the use of low temperature distillation, more than 90 percent of the propane from the crude and cracking units is recovered as liquefied product. Also, the recovery system is designed so that ethylene can be recovered in the future by the addition of much less new equipment than would have been required if a conventional absorption system had been utilized.

The separation and recovery unit is comprised of a gasoline stripper, a deethanizer, a debutanizer and a propane refrigeration system. The deethanizer and the debutanizer are both about 80 feet tall and the gasoline stripper is 60 feet tall. The gasoline stripper operates at 250 psi and a refrigerated top separator temperature of 60°F. The deethanizer operates at 500 psi and a refrigerated top separator temperature of −10°F. The debutanizer operates at a pressure of 145 psi and the overhead is cooled with water.

Gasoline and gas from the viscosity breaker and combination cracking units flow directly to the recovery unit. All the fuel gas and some of the propane and butanes are stripped from the gasoline fractions in the gasoline stripper. The vapor from the gasoline stripper together with the viscosity breaker and cracked gases are compressed and refrigerated and charged to the deethanizer where the ethane and lower boiling hydrocarbons are separated as fuel gas. The bottoms, consisting of propane and heavier hydrocarbons, flows together with the gasoline from the stripper to the debutanizer. The propane-butane fraction passes overhead and the butane-free gasoline is withdrawn from the bottom of the debutanizer.

The catalytic polymerization unit is a combination unit with one set of reactors for selective polymerization (i.e., the production of codimer) and the second set for non-selective polymerization (production of motor gasoline). The catalyst is phosphoric acid on quartz and the process is operated under license of the California Research Corporation. The unit is comprised of two sets of reactors and the necessary fractionating towers to separate and recover codimer, debutanized polymer gasoline, butane and propane. The selective reactors operate at 500 psi and 300°F maximum temperature and the non-selective reactors operate at 500 psi and 400°F maximum temperature. From an average Venezuelan crude oil the codimer production will be 720 barrels per day, the polymer gasoline 840 barrels, the butane 1,500 barrels and the propane 1,500 barrels.

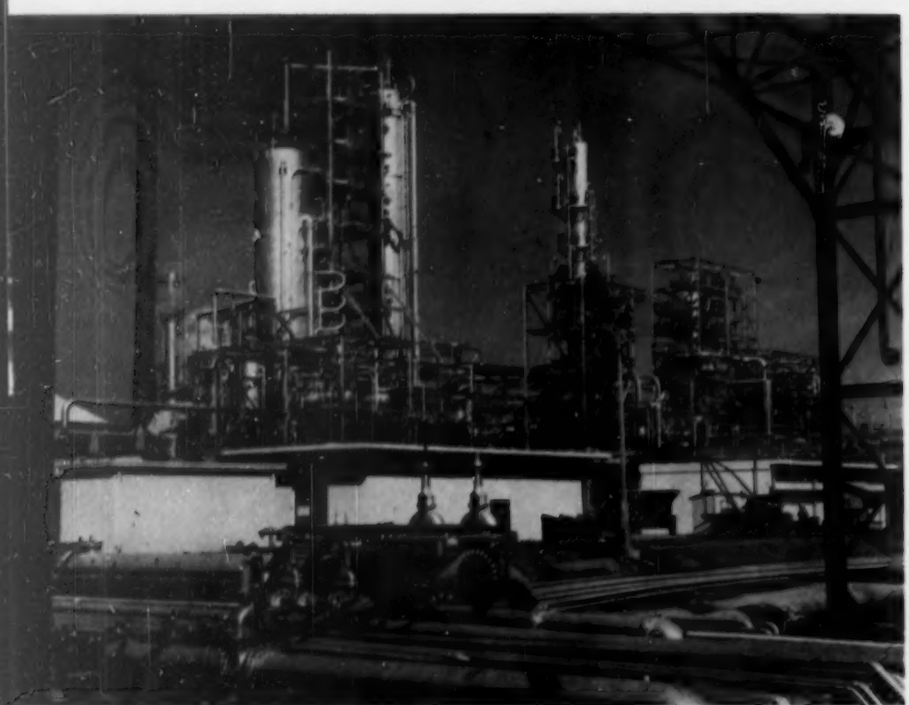
Treating facilities are provided primarily for the elimination of gum-forming constituents of the gasoline and sulfur compounds of various products. Gasoline from the viscosity breaker and from the combination reformer and cracker is clay treated in the vapor phase. Gasoline is also caustic washed, copper sweetened and treated with tannin solutizer. Fuel gas is scrubbed with diethanol amine. Propane-butane feed to the catalytic polymerization unit is washed with diethanol amine and caustic. Isopentane is caustic washed. Kerosine is washed with liquid sulfur dioxide in an Edeleanu unit. Diesel fuel is caustic washed.

The gasoline blending unit is comprised of blending tanks and circulating pumps and facilities for adding tetraethyl lead, gum inhibitor and dye. To blend motor gasoline, the required proportions of light straight run gasoline, cracked gasoline, polymer gasoline and butane are run to one of the blending tanks. The lead tetraethyl, dye and gum inhibitor are added necessarily while the contents of the blending tank are thoroughly mixed, by circulation through the pumps and back to the blending tank.

* * *

The authors gratefully acknowledge the assistance of Mr. J. H. Arnold in the preparation of this manuscript.

INDIA'S biggest refinery now on stream



The crude distillation unit (left) and the feed preparation unit (right) of the Trombay refinery of Burmah-Shell Refineries Ltd. All photos used in this article through the courtesy of Burmah-Shell Refineries Ltd.

The main control room of the crude distillation unit of the Trombay refinery.

INDIA'S LARGEST refinery, with a capacity of 40,000 barrels daily, is now in full operation. Located at Trombay Island in the Bombay harbor area, the installation of Burmah-Shell Refineries Ltd. was formally declared open March 17 by Dr. S. Radhakrishnan, vice president of India. At that time, the crude oil distilling unit and associated treaters were the only process plants on stream. Since then, the catalytic cracking complex has been started up, and the refinery is currently producing a complete line of products for the Indian market.

Decision to build the Indian plant goes back to the period soon after World War II when the companies thoroughly investigated the question. The Government of India showed keen interest in the development of the petroleum industry and in 1947 invited the oil companies to examine the possibilities. Five major companies responded, and a technical survey was made the next year. One member of the survey party was H. J. Trow, now general manager and managing director of Burmah-Shell Refineries, Ltd.

Based on the results of the survey, a comprehensive report was prepared, recommending Bombay and Visakhapatnam as the most suitable refinery locations. Following this, Burmah-Shell indicated its willingness to provide a modern oil refinery at Bombay.

Burmah-Shell Refineries Ltd. is jointly owned by the Burmah Oil Co. Ltd. and the Anglo-Saxon Petroleum Co. Ltd. (a Royal Dutch/Shell Group company). Products from the refinery will be marketed by Burmah-Shell Oil Storage and Distributing Co. of India Ltd., jointly owned by the Burmah Oil Co. Ltd. and the Shell Petroleum Co. Ltd., (a Royal Dutch/Shell Group company). Thus, the Burmah-Shell organization has taken a major step towards establishing an industry capable of supplying a considerable part of India's requirements of refined petroleum products.

The construction of this and the other new refineries of India, that of the Standard-Vacuum Refining Co. of India Ltd. adjacent to the Burmah-Shell refinery at Trombay and that of Caltex (India) Ltd. at Visakhapatnam on the east coast of India, represent an investment of more than $125 million. Most of this sum is overseas capital provided by the oil companies concerned and indicates the confidence of foreign capital in the future of India.

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New Houdresid Process Completely Cracks the Bottom of the Petroleum Barrel, Increases Gasoline Yields.

The Houdry Process Corporation has announced an economically feasible process for catalytically cracking the bottom of the petroleum barrel. The new process, named *Houdresid*, converts reduced crudes into the most desirable refinery products.

Houdresid eliminates the need for expensive feed preparation processes. It also accomplishes a marked increase in gasoline yield; approximately 64 per cent gasoline is produced from the residuum as compared with 52.5 per cent gasoline yield from vacuum distillation plus catalytic cracking.

The Houdresid Process has been on stream for more than a year at the Sun Oil Refinery at Sarnia, Ontario.

For further information write to: Houdry Process Corporation, 1528 Walnut Street, Philadelphia 2, Pennsylvania.

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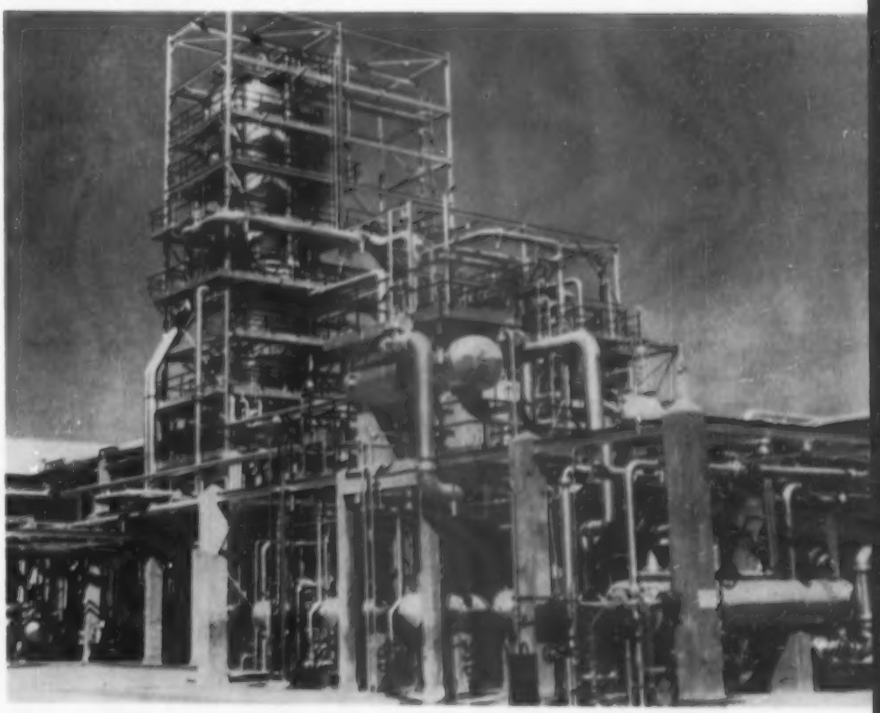
PIONEER IN CATALYTIC PROCESSES

The catalytic cracking unit.

The feed preparation unit.



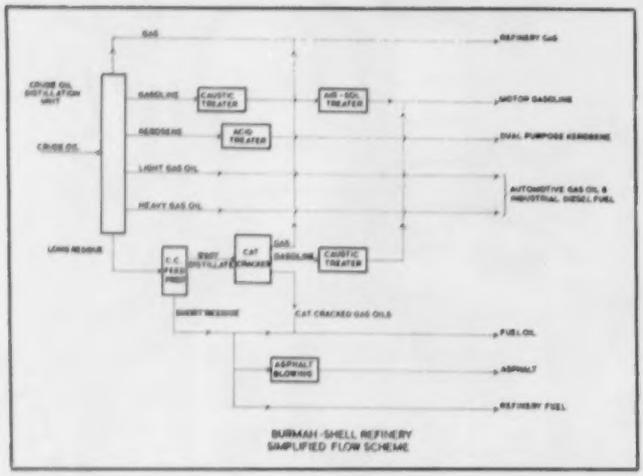
Bombay was chosen as the refinery site by Burmah-Shell Refineries Ltd. for several reasons. It is the nearest main port to the expected source of crude oil; it has an excellent harbor, adaptable to the needs of a modern oil terminal; and from the harbor also can be drawn the cooling water required by a large refinery. Moreover, about three quarters of India's requirements of oil products are handled on the west coast, and Bombay is connected with the interior by a fine railway network as well as by roads. Hence, refinery products can be distributed easily; in fact, the distribution of imported products was already being carried out on a considerable scale from Bombay as a center.

Due to the shutdown of the refinery at Abadan, with consequent loss of refined products, arrangements for erection of the refinery were speeded up. The refinery agreement between the Government of India and the Burma-Shell group of companies was signed December 15, 1951.

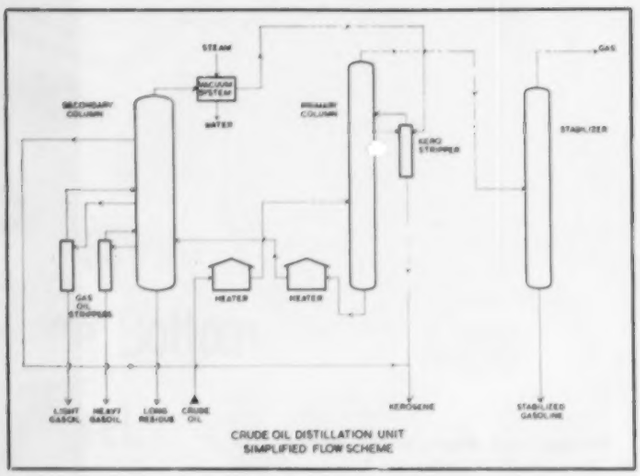
Preliminaries and planning for the refinery took most of 1952. Existing maps of the site were not sufficiently detailed, and arrangements were made with the Survey of India to prepare new maps by a combination of air and ground survey. To establish the requirements for foundations, exploration of the sub-surface was carried out.

The Government of Bombay had agreed to acquire the site for Burmah-Shell under the normal Land Act acquisition procedure. As a first step, the boundaries had to be established by government surveyors and recorded on the village maps used for land record purposes. This was done, and the agreement for obtaining the site was signed with the Collector of Bombay on January 15, 1953. A month later, boundary pillars were sunk in the ground as a start in taking possession of the land.

Before construction could begin, two other engineering jobs had to be completed. One was moving the Bombay Port Trust Railway and also the pipe lines through which were pumped practically all of the "white" petroleum products for Bombay. The other was reclaiming the salt pans which composed a large part of the site. It was only after the two tasks of railway and pipe line relocation and of salt pan reclamation were completed that actual



BURMAH-SHELL REFINERY
SIMPLIFIED FLOW SCHEME



CRUDE OIL DISTILLATION UNIT
SIMPLIFIED FLOW SCHEME

construction could be commenced. Meanwhile, where possible, the site had been cleared.

Of the usual construction details—for example, erection of columns—little need be said here. However, mention should be made of the two monsoon seasons. During 1954, there were 170 inches of rain, more than 100 inches above the average and setting a new record. With careful phasing of the work, so that the heavier construction was completed before the onset of the monsoon each year, the effect of the heavy rains was alleviated to some extent. Nevertheless, progress was slowed down considerably.

To accommodate the Burmah-Shell and Stanvac refineries on Trombay, facilities for unloading petroleum had to be greatly expanded. Accordingly, a marine terminal has been constructed on Butcher Island by the Bombay Port Trust. From off-shore jetties, tankers can pump crude oil through pipe lines on trestles to Butcher Island and thence by underwater pipe lines to a manifold on Trombay Island. From this manifold, the crude oil can be transferred to the tanks of either refinery. The facilities of the marine terminal, up to and including the manifold, are operated by the Bombay Port Trust.

Private enterprise, on the other hand, is building the Bombay Terminal Power Station. This plant of Tata's will be fueled by refinery products, and as of next year will furnish electric power to both refineries on Trombay Island. In the meantime, power is being supplied by other parts of the Tata system.

In one sense, construction of the refinery will never be complete. But with all units now in operation, what products does India's largest refinery make and what are the steps involved? From 2,000,000 tons of crude will be manufactured annually: 500,000 tons of motor gasoline; 255,000 tons of kerosine; 138,000 tons of automotive gas oil; 127,000 tons of industrial diesel oil; 667,000 tons of fuel oil; and 150,000 tons of bitumen. The following is a brief description of the general refinery flow:

Crude oil for the refinery arrives in tankers which are unloaded at the newly constructed Butcher Island marine terminal. From the marine terminal, the crude oil is pumped through underwater pipe lines to the crude oil tank farm of the refinery.

From this tank farm, the crude oil is charged to the distilling unit, which produces both intermediate and finished products. The straight-run gasoline and the kerosine are finished by chemical treatments, light and heavy gas oils are used as such for middle distillates, while the long residue is charged to the vacuum flashing unit which provides the charging stock for the catalytic cracking unit.

In addition to cat cracker feed, the vacuum flasher unit produces short residue, part of which is passed to an asphalt blowing plant, the balance being used either as refinery fuel or as a fuel oil component.

The waxy distillate fed to the catalytic cracking unit is converted into gas, cracker gasoline, light and heavy catalytic gas oils and coke. The coke formed is consumed in the process. The gas and gasoline pass through the compression system and thence to the fractionating columns of the gas recovery section. Part of the gas is used as refinery fuel, while the gasoline is charged to treating facilities. The light and heavy catalytic gas oils recovered from the cat cracker product fractionator are blended into fuel oil.

Finished motor gasoline is prepared by first caustic scrubbing and sweetening the straight-run and cat cracked components and then adding inhibitor, dye, and tetraethyl lead to the actual blends. Also added is "I.C.A.," as Shell's "T.C.P." is known outside the United States and Canada. The kerosine fraction from the crude distilling unit is acid treated so as to bring it up to specification for marketing.

Both white products and black oils are transferred from the refinery by pipe line to two near-by terminals. Sewri, located about four miles away, handles automotive gas oil, kerosine and gasoline. About three miles farther is Wadi Bunder. This is within the port area and is restricted to the handling of black oil, i.e. diesel fuel and fuel oils. Products are also delivered from the refinery by means of rail tankers.

Crude Oil Distilling Unit: The distilling unit was designed for an intake of 6,000 metric tons of Kuwait crude oil per stream day. It consists of a primary and a secondary column, a stabilizer, and three strippers.

Crude oil is pumped from storage through several heat exchangers, then partially vaporized in a furnace, and charged to the primary column. Unstabilized gasoline is taken overhead, condensed and fed to the stabilizer. The column produces 9.0 psi RVP gasoline as a bottom product, the light hydrocarbons comprising the top product being routed to the refinery gas system. The stabilized straight-run gasoline is caustic-treated prior to being sweetened. Light kerosine is withdrawn as a side-stream from the primary column and stripped in the kerosine stripper.

The primary column bottom product is further heated and then charged to the secondary column, which operates at 300 mm Hg absolute pressure. In addition, stripping steam is injected. The over-head vapors pass to the vacuum system and are condensed, the water being drained and the hydrocarbon phase transferred to the kerosine stripper of the primary column. Heavy kerosine is withdrawn directly as a side-stream from the secondary column. Light and heavy gas oils are similarly withdrawn and are stripped in separate strippers.

The light and heavy kerosine streams are run down together to intermediate storage, prior to being charged to the kerosine acid treater.

The light and heavy gas oils are cooled and sent to storage, before being blended into middle distillates for sales.

The long residue from the bottom of the secondary column, after heat exchange with the crude oil, is either fed hot to the vacuum flashing unit or is cooled and transferred to storage.

Cat Cracker Feed Preparation Unit: Vacuum flashing is used for the preparation of cat cracker feedstock from long residue. The design of the unit is essentially the

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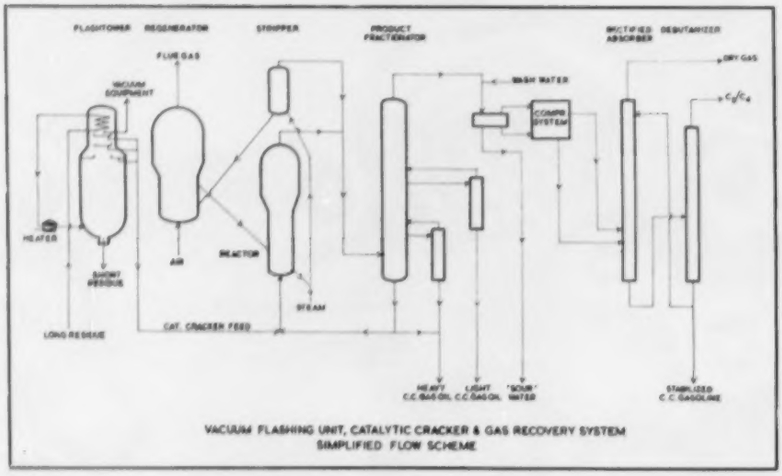

VACUUM FLASHING UNIT, CATALYTIC CRACKER & GAS RECOVERY SYSTEM
SIMPLIFIED FLOW SCHEME

same as that used in certain of the European refineries of the Royal Dutch/Shell Group.

Normally, long residue is charged hot from the crude oil distilling unit. The feed pumps of the feed preparation unit circulate this material first through internal vapor-to-feed exchangers, then through bottoms-to-feed exchangers, and finally through a heater and into the bottom of the flash tower. Here the pressure is 40-60 mm Hg absolute, and the resulting flash vaporization produces the primary separation between distillate and short residue.

The vaporized distillate passes upward through demisters, which reduce the entrainment of asphaltenes and metal contaminants in the cat cracker feed. The residual material removed by the demisters is recycled to the feed line. Part is cooled and recycled to the entrainment removal plate, where its washing action minimizes coke deposition.

Vapor leaving the demisters continues upward, past a top deck, through the flash tower and then downward over the internal vapor-to-feed exchangers. The condensate formed is withdrawn to the distillate accumulator. Vapor leaving the exchangers then passes over internal water-cooled condensers. The condensate so produced is also transferred to the distillate accumulator. This vessel also receives the liquid which condenses on both the tower walls above the top deck and the shell enclosing the internal exchangers and condensers.

Uncondensed vapor from the flash tower is sent to a condensing tower, where part of the vapor is condensed by contact with cooled condensate refluxed through the tower. This material is injected into the distillate from the accumulator, and the combined stream either goes hot to the cat cracker or is cooled before being transferred to storage.

From the top of the condensing tower, the remaining uncondensed vapor is withdrawn at 20 mm Hg absolute pressure by a three-stage set of steam ejectors. Uncondensable gases are burned, and the condensate is routed to the oil catchers.

Short residue from the bottom of the flash tower is pumped, first through the bottoms-to-feed exchangers, then through steam generators, and finally either to the asphalt blowing unit, refinery fuel or to storage preliminary to being blended into fuel oil.

Catalytic Cracking Unit and Gastail: Vital to the over-all operation of the refinery is the catalytic cracking unit. The primary function of the catalytic cracker is to produce motor gasoline of high quality, essentially from long residue. When processing Middle East crude oils, the blend of light and heavy catalytic cracked gas oils with short residue from the feed preparator has practically the same viscosity, and almost as low a sulfur content, as the long residue. Thus, the heavy fuel oil "pool" is nearly unchanged in these respects, while undergoing a reduction in quantity through catalytic conversion of part of the residue to gas, gasoline and coke.

The Bombay catalytic cracker is of the heat-balanced type and has a rated fresh feed capacity of 1,825 metric tons of flashed distillate per stream day. Although using the well-known fluid bed process, the unit embodies a number of design features for efficient operations, reduced capital outlay and decreased maintenance.

The reactor and regenerator are placed at low elevation, with an external stripper vessel located above, and supported by, the reactor. This arrangement reduces the cost of the structure, since the stripper is considerably smaller than the other two vessels. Further, only one riser is required; this carries spent catalyst from the reactor to the stripper and provides efficient dispersed phase stripping, with steam serving as both transport and stripping medium.

The slide valves were designed for low pressure drop; this reduces erosion and allows reduction in the over-all height of the unit to 115 feet.

By using swaged vessels and by designing for a relatively high pressure in the reactor (18 psig) and regenerator (20 psig), a larger height/diameter ratio is provided for the dense beds, and low linear velocities are obtained above the beds. The larger height/diameter ratio improves the contacting efficiency between vapor and catalyst in the dense beds, while the low linear velocities reduce the catalyst loading of the cyclones.

At Bombay, the normal cat cracker feed is mainly hot product from the feed preparation unit, to which is added cold feed from storage for temperature control. Upon contact with hot, regenerated catalyst, the feed is vaporized. It then enters the reactor. Catalyst to be regenerated is transferred first to the stripper for removal of absorbed and entrained hydrocarbons. The stripped catalyst is then regenerated by burning off the coke. It is the heat from this combustion which supplies both the heat of reaction and the latent and sensible heat requirements for the process, including product fractionation. Still in the vapor state, the reaction products leave the reactor and together with the vapor from the external stripper, pass to the product fractionator.

The small amount of catalyst leaving the reactor and stripper cyclones with the vapor is concentrated by the fractionator in the slurry oil. Most of this stream is recycled to the reactor, after being used as a heat transfer medium, and the remainder goes to storage, where the residual catalyst settles out. Light and heavy cracked gas oils are withdrawn as sidestreams and stripped separately. These products are then transferred to storage, pending blending into fuel oil.

Gas and unstabilized gasoline are taken overhead on the fractionator, passed through condensers, and collected in the overhead accumulator. Wash water is injected into the vapor line ahead of the condenser. This water and condensed steam are withdrawn from the accumulator as "sour water" and transferred to storage before disposal. The hydrocarbon liquid and vapor are transferred to the compression system. Here two-stage reciprocating compressors, driven by gas engines, take suction on the vapor. To the vapor from the first stage is added the liquid from the fractionator accumulator. Wash water is injected and the entire stream passes through condensers to the second-stage dry drum, where "sour water" is drained and transferred to storage. "Sponged" vapor enters the second stage of the compressor and the equilibrium liquid is discharged from a pump to the gas recovery system.

Vapor from the second stage is also transferred to the gas recovery system. It is cooled and charged, as is the liquid, to a rectifying absorber. This column is reboiled and uses stabilized gasoline as lean absorber oil and light cracked gas oil as lean sponge oil, the "rich" sponge oil being returned to the product fractionator. Recovered in the absorber bottom product are 98-99 percent of the C_4 fraction and up to 95 percent of the C_3 fraction in the feed. The dry gas from the top of the absorber is burned as refinery fuel, and the bottom product is charged to the debutanizer.

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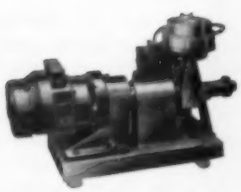

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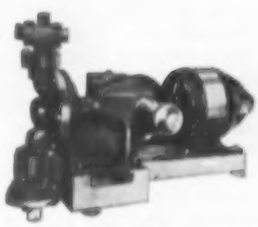

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PLUNGER PUMPS as single units with ram diameters of from $\frac{1}{2}$-in. dia. to 4-in. dia. and capacities of from 5 ml. to 500 gallons per hour and pressures up to 20,000 lb. per square inch.
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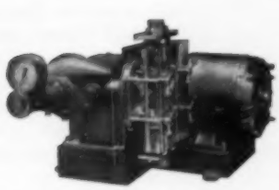

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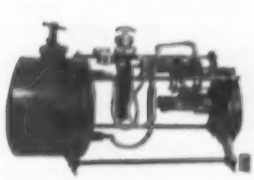
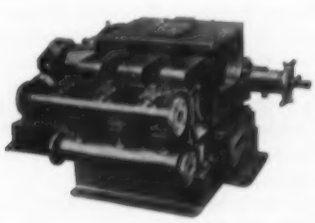
Twin G/250 diaphragm pumps. Can be supplied in multiple units of eight or ten pumps.



Pneumatic chemical feeder driven by natural gas or compressed air.



Present operation of this column is stabilizing the cracked gasoline, although it can be operated for complete debutanization. Propane-propylene and excess butane-butylene are taken overhead and routed to the refinery gas system. Part of the stabilized cracked gasoline is recycled as lean absorber oil, and the net production is withdrawn for treating.

Asphalt Blowing Unit: The asphalt blowing unit produces several grades of semi-blown asphalt as required by the Indian market. Short residue, the bottom product from the feed preparation unit for the cat cracker, is normally charged hot. Alternatively, it can be charged "cold" (265°F) from storage.

Hot feed is further heated by exchange with the product and is then pumped to the blowing column. Here it is blown with the required amount of air, which is supplied via a receiver from an air compressor in the plot. For maximum heat recovery, the blown product is routed first through a steam superheater, then the feed exchanger, and finally to a waste heat boiler.

With cold feed, neither the steam superheater nor the waste heat boiler is used. Instead, after the product exchanger the feed goes through a furnace before entering the blowing column. All of the heat in the blown product is used to heat the cold feed.

In either case, steam is injected into the top of the column to keep the temperature of the gases lower than the reaction temperature and thus prevent after-burning. The reaction temperature is of course higher than the feed temperature, because of the heat released by the oxidation of the asphalt.

The gases leaving the top of the blowing column are subjected to stepwise cooling. As a result, blown distillate, oily condensate and non-condensable gases are produced as separate streams. The blown distillate is routed to storage, the oily condensate to the refinery oil catchers, and the non-condensable gases (because of their obnoxious odor) to a furnace.

The blown asphalt is transferred to storage.

Gasoline Treating: Before being sweetened, the catalytically cracked and straight-run gasolines are scrubbed with caustic soda. In addition to possible traces of H_2S, the catalytically cracked gasoline contains so-called "acid-oils," i.e. thiophenols and alkylphenols. The thiophenols (arylmercaptans) are readily removed, but satisfactory reduction in the alkylphenol content requires more severe conditions. Thus, two-stage countercurrent treatment with caustic soda has been provided at Bombay. This removes any H_2S present and part of the lower molecular weight alkylmercaptans.

Following the two mixer-settler stages, the catalytically cracked gasoline is sweetened by the injection of air and inhibitor. In case there is not enough carry-over of caustic for rapid air-inhibitor sweetening, additional caustic soda can be injected by a special pump.

Because only compounds of fairly high acidity have to be removed from the straight-run gasoline, just one mixer-settler stage for scrubbing with caustic soda was installed. This is sufficient to remove possible traces of H_2S and also to extract some low molecular weight mercaptans.

Air-inhibitor sweetening not being applicable to olefin-free fractions, another type of sweetening process had to be chosen for the straight-run gasoline. In preference to either doctor treating or a mercaptan extraction process, air-solutizer sweetening was selected. This mercaptain conversion process was developed by the Royal Dutch/Shell Group and is essentially a modification of the well-known solutizer process for mercaptan removal.

The single-stage treatment of straight-run gasoline with caustic soda removes certain potential contaminants of the solutizer solution. However, to avoid contamination with sodium, carry-over of caustic soda must be minimized.

For this purpose, a coalescer was installed ahead of the equipment used for the sweetening proper. The latter consists of one mixer-settler stage, with the mixing facilities arranged to provide the proper combination of mixing intensity and contact time. After the settler, there is a coalescer to complete removal of the solutizer solution.

Also included in the air-solutizer treater are reconcentration facilities for periodic removal of water from the solutizer solution. This, plus make-up of the other constituents, maintains the required inventory and optimum composition of the solutizer solution.

Kerosine Acid Treater: For supplying a product meeting the specifications for dual purpose kerosine, acid treatment of the straight-run kerosine fractions is required. The acid treater is equipped with three mixer-settler stages, in which the kerosine is contacted with sulfuric acid in countercurrent flow. The acid contacting stages are followed by an acid coalescer, one mixer-settler stage for neutralization with caustic soda, and a mixer-coalescer for water-washing the product.

By maintaining the proper conditions during acid treating, a doctor negative product is obtained, while substantial desulfurization takes place with comparatively little acid consumption.

Spent caustic and wash water are discharged to the refinery oil catchers via a neutralization pit, to which all vessel drains are connected. The acid sludge is routed partly to the waste disposal system and partly to an acid sludge storage tank.

Water Disposal: To eliminate any deleterious or nuisance effects of spent chemicals, a waste disposal plant was built. This plant handles the following streams:

(a) "Sour" water from various water-washing stages in the catalytic cracker.

(b) Spent caustic soda from treatment of catalytically cracked gasoline.

(c) Spent caustic soda from treatment of straight-run gasoline.

(d) Sulfuric acid sludge from treatment of kerosine.

The spent caustic soda from treatment of catalytically cracked gasoline is neutralized batchwise. After dilution with an equal volume of water (see later), the spent caustic is gradually neutralized by a stream of acid sludge from kerosine treating. The gases evolved are removed by a purge stream of fuel gas, to be burned in a waste products furnace. Neutralization results in the formation of two layers. The oily top layer is burned, and the aqueous bottom layer is transferred to a homogenizing tank.

Into this same tank are delivered the "sour" water from the catalytic cracker and the spent caustic soda from treatment of straight-run gasoline. The homogenized contents of the tank then undergo continuous neutralization with acid sludge (from kerosine treating) and subsequent stripping with steam and fuel-gas. The neutralized and stripped water, bottom product from the stripper, is discharged to the refinery oil catchers. It is part of this water which is used for the batchwise dilution of spent caustic soda from treating catalytically cracked gasoline. The top product from the stripper passes through a condenser for removal of part of the steam and is then burned either in the boiler house or in the waste product furnace.

Acid sludge not required for neutralization is neither sold or burned. The portion to be burned is enriched with fuel oil, homogenized and atomized with steam in a special nozzle in the waste products furnace.

Utilities, Tankage and Amenities: Besides the process units described above, other facilities are necessary for operation of the refinery. Reference has already been made to the Butcher Island marine terminal and the Trombay terminal power station. In addition, the municipality of Bombay supplies fresh water to the refinery.

Other utilities are supplied by the refinery itself. Three boilers, each with a normal capacity of 30 metric tons per hour, furnish steam at 256 psig and 707°F. Cooling water is taken from the harbor and pumped to a suction basin for the pumps which actually supply the refinery. The cooling water is used on a once-through basis, being discharged back to the harbor at some distance from the intake.

Tankage is provided for crude oil and for both intermediate and finished products. In addition to the conventional equipment for adding dye, inhibitor, and tetraethyl lead to the finished motor gasoline, there are facilities for injecting "I.C.A."

The analytical facilities necessary to control product quality and guide plant operations are housed in a laboratory of modern design. The administrative building is also of contemporary architecture, with functional provisions for the climate. In similar style are the medical center and canteen. There also are staff housing and a housing colony. The laying of the foundation stone for the latter was performed by the Prime Minister of India, Mr. Jawaharlal Nehru.

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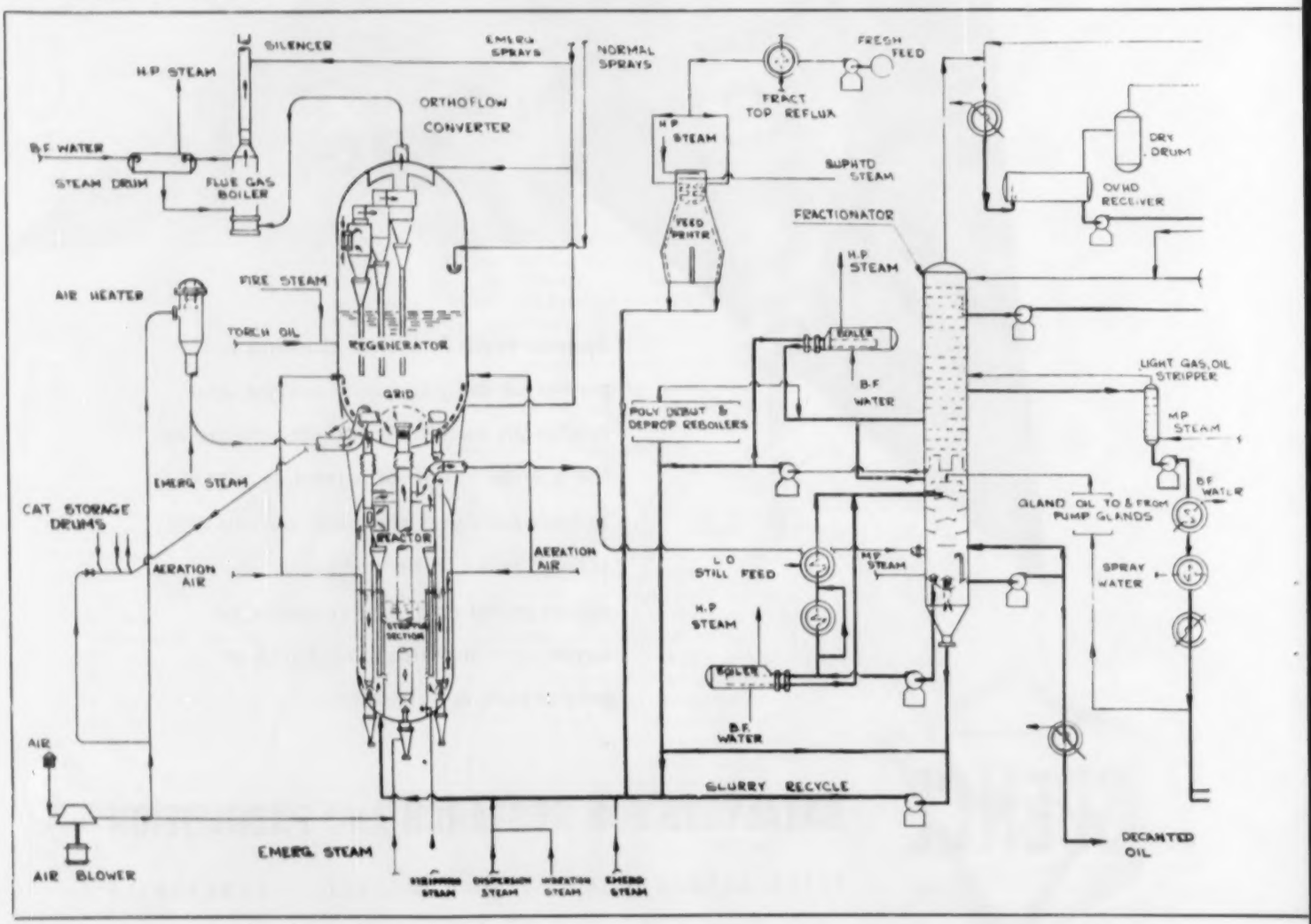
By J. L. Porter

John Lawrence Porter started as a chemist for British American Oil Co. Ltd. in Montreal and Toronto and was then appointed refinery chemist at Moose Jaw, Calgary and Toronto. He became assistant superintendent at the Moose Jaw refinery and then worked for a while on special assignment dealing with the prevention of pollution at the Clarkson refinery. In 1948 he was appointed engineer at head office, and in 1952 head of the process engineering division, manufacturing department. He has done extensive project work, process engineering and pollution and loss assignments in the engineering field.

THE INCREASING demand for higher octane gasolines to meet the requirements of late model automobiles had led to large capital expenditures by the Canadian petroleum industry. One of the most ambitious programs of refinery construction to further the manufacture of improved quality products is currently being implemented by The British American Oil Co. Ltd.

In June 1954, at the Clarkson, Ontario refinery, British American placed on stream the fourth catalytic cracker the company has built since 1946. The Clarkson unit was a Model B Orthoflow fluid catalytic cracker, the first of its kind in Canada. British American has pioneered in the use of Orthoflow fluid cat crackers in Canada—the Model A Orthoflow built at the Edmonton

Flow diagram of the Orthoflow cracking unit at the Clarkson, Ontario refinery of British American Oil Co. Ltd.



REFINERY CONSTRUCTION PROGRAM

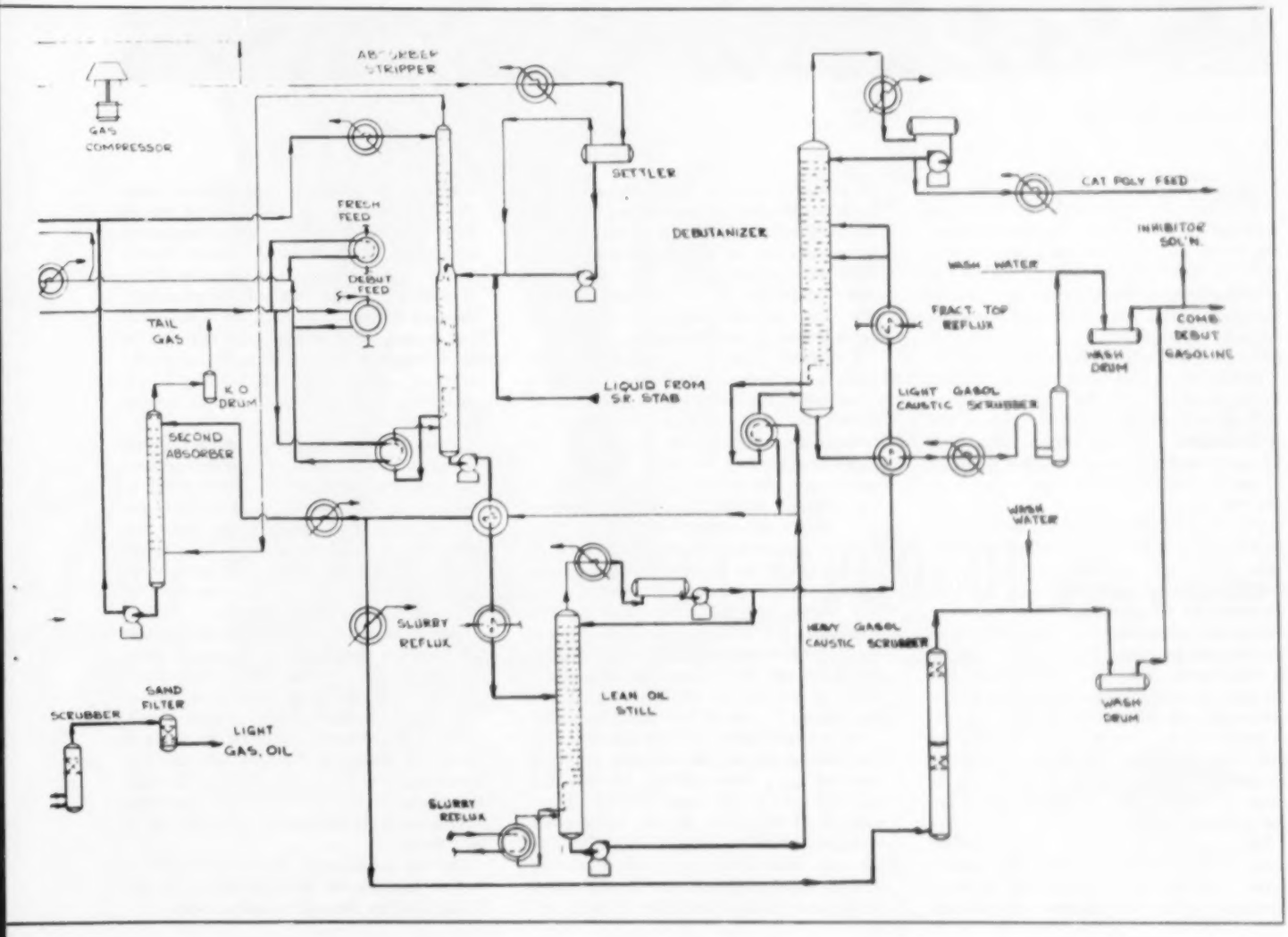
refinery in 1951 was the first of its type in the world. Both these units were engineered and constructed by the Canadian Kellogg Co. Ltd.

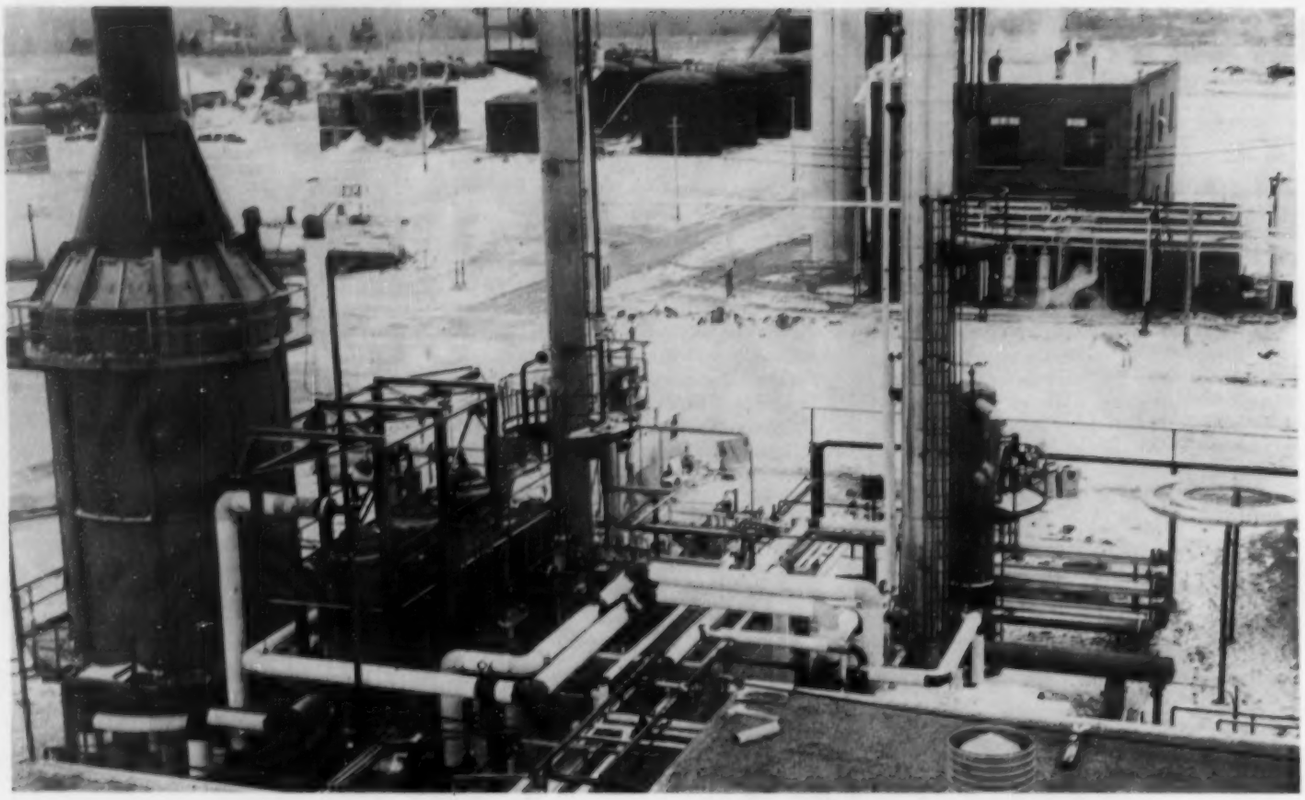
The Model B Orthoflow is one of two versions of Kellogg's exclusive fluid designs for catalytic crackers. Both designs involve stacked vessel construction with straight-line catalyst flow. The principal difference between them is the position of the regenerator which, in the Model A, is below the reactor and in the Model B above it. One advantage obtained with the latter design is reduction in air pressure at which the regenerator operates. Another is a decrease in the size of the reactor and of the fractionator—a result of the higher operating pressure of the reactor. Also, the gas compressor suction pressure is higher and an additional power saving results.

The new fluid catalytic cracking unit, together with its accompanying gas recovery and catalytic polymerization equipment, has been designed to process 11,610 b/sd of mixed gas oils from the topping and vacuum units which are run on a mixture of Western Canadian and Mid-Continent U. S. crudes. The products obtained from the fluid cracking unit are a 400° F end point, 7.5# rvp debutanized gasoline, light gas oil, decanted oil, catalytic polymer feed and fuel gas.

Catalytic Cracking Section: Fresh gas oil charge stock is introduced to the unit from storage. The fresh feed, preheated by exchange with top reflux from the frac-

The Model B Orthoflow fluid catalytic cracking unit at Clarkson is the first of its type in Canada.





British American's catalytic reforming unit at Calgary.

tionation section and then in a feed preheater furnace, together with recycle gas oil from the fractionator hot catalyst bearing slurry oil from the fractionator settler, flows to the Orthoflow converter where the cracking reaction and the catalyst regeneration take place. This Orthoflow converter contains reaction, catalyst stripping, regeneration and catalyst circulation facilities.

Powdered natural catalyst is maintained in fluidized beds in the reactor, stripper and regenerator by upflowing vapors and is circulated from one section to another by maintaining different catalyst densities in the catalyst circulation lines to and from the regenerator.

The upper section of the Orthoflow converter is the catalyst regenerator, in which coke deposited on the catalyst during cracking is removed by burning. The heat liberated by the combustion of this coke raises the temperature of the catalyst in the regeneration zone. Regenerated catalyst is withdrawn from the regenerator bed through a standpipe and plug valve and is contacted with oil feed and a small amount of steam in the bottom of the reactor. At this point heat from the catalyst serves to completely vaporize the oil feed and to raise its temperature to that required for the cracking reaction.

The reaction section of the Orthoflow tower is located directly below the regenerator. The fluidized catalyst bed depth is controlled at the level necessary to provide the contact time with the oil vapor required to obtain the desired conversion. Above the fluidized bed there is a disengaging space for separation of the powdered catalyst from the cracked vapors. The vapors then pass out of the reactor through cyclones which recover the catalyst which has been carried through the disengaging space.

The spent catalyst is withdrawn from the reactor bed to the stripper which is contained in the lower portion of the tower within the reactor. The entrained hydrocarbons are stripped with steam from the spent catalyst and the steam and stripped vapors are vented through the open top of the stripper section into the disengaging space above the reactor bed.

The stripped spent catalyst flows from the bottom of the stripper through a plug valve and into the spent catalyst carrier line which, like the regenerated catalyst standpipe, is a straight line located within the Orthoflow vessel. Sufficient air is introduced through the hollow stem of the plug valve to convey the catalyst upward into the regenerator below the distribution grid.

Air for combustion of coke laid down on the catalyst during the reaction period is supplied by a motor-driven blower, and except for the amount used to lift the spent catalyst, is delivered to the regenerator through a distribution grid ring. The flue gas from coke combustion passes upward through the disengaging zone for separation of gas and catalyst and then through cyclones to the flue gas boiler where waste heat is recovered in the form of steam. From the boiler the flue gas is vented to atmosphere through a stack. An air heater which is an integral part of the air inlet line is used during startup periods to supply the heat necessary to raise the regenerator bed temperature to the level required to start combustion of fuel oil in the regenerator bed, after which the burning of oil raises the bed temperature to its normal operating level.

The rate of catalyst circulation through the system is controlled by the regenerated catalyst plug valve which is regulated to transfer to the reaction zone the amount of hot catalyst necessary to maintain the desired reaction temperature. The spent catalyst plug valve returns the catalyst to the regenerator at the rate required to maintain reactor catalyst holdup.

Two drums are provided for the storage of catalyst. One catalyst drum is large enough to hold the operating catalyst inventory. The other drum is large enough to hold two carloads of fresh catalyst. Fresh catalyst is unloaded from cars by using a steam jet ejector to partially evacuate the fresh catalyst drum. Air flowing through the unloading piping from the car into the evacuated drum carries the catalyst with it as a fluid.

Dry air for aeration, air-motor-operated valves, instruments and instrument bleeds is supplied by the central air system.

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Fractionation and Gas Recovery Section: Cracked hydrocarbon vapors, steam and inert gas which entered the reactor with the regenerated catalyst flow from the reactor to the base of the fractionator tower. Here the vapors are cooled and washed free of catalyst in the scrubbing section. Sufficient cooling is done by the circulation of slurry reflux over baffles and by down-flow from the tray above to desuperheat the entering material and to condense the slurry recycle and decanted oil. Heat removed from the tower by the slurry reflux is used for reboiling the gas recovery lean oil still, preheating the lean oil still feed and the generation of steam in the slurry boiler.

The tray between the top of the scrubbing section and the heavy gas oil drawoff pan removes any entrained slurry reflux or catalyst that may have been carried up from the baffles below. Above this tray is a total drawoff pan which collects the heavy gas oil which in turn is used as reflux for the tower and as recycle to the reactor. Heat is removed from the reflux stream in the intermediate reflux boiler with steam production and by reboiling the catalytic polymerization unit depropanizer and debutanizer.

A stream of light gas oil product and gland oil is drawn from the tenth tray of the fractionator through the light gas oil stripper. The stripped gas oil is caustic washed, sand filtered and sent to storage.

TABLE 1

Typical Catformer Operating Conditions, Yields and Product Analyses

Throughout—2000 b/sd
Space Velocity—3.0 (pounds per hour naphtha per lb. catalyst)
Reactor Pressure—700 psig on the middle reactor
Reactor Inlet Temperature—900°F.
Recycle Rate—10 mols recycle gas per mol naphtha

Anticipated Yields	*To 85 F-1 Clear Debut. Reformate* Vol. %	Wt. %
Hydrogen		1.1
Methane		.18
Ethane		.36
Propane		3.1
Butane	9.7	—
Debut. Reformate	86.5	—

Product Analyses	*Feed*	*Debut. Reformate*
API Gravity	56.2	49.6
RVP	3.9	5.1
Wt. % Sulfur	0.1	.001
ASTM Dist.		
IBP	127	124
10	178	168
50	260	235
90	360	332
FBP	402	422
Research Oct. Clear	53.4	85.0
+ 3.6 cc TEL	70.8	95.8

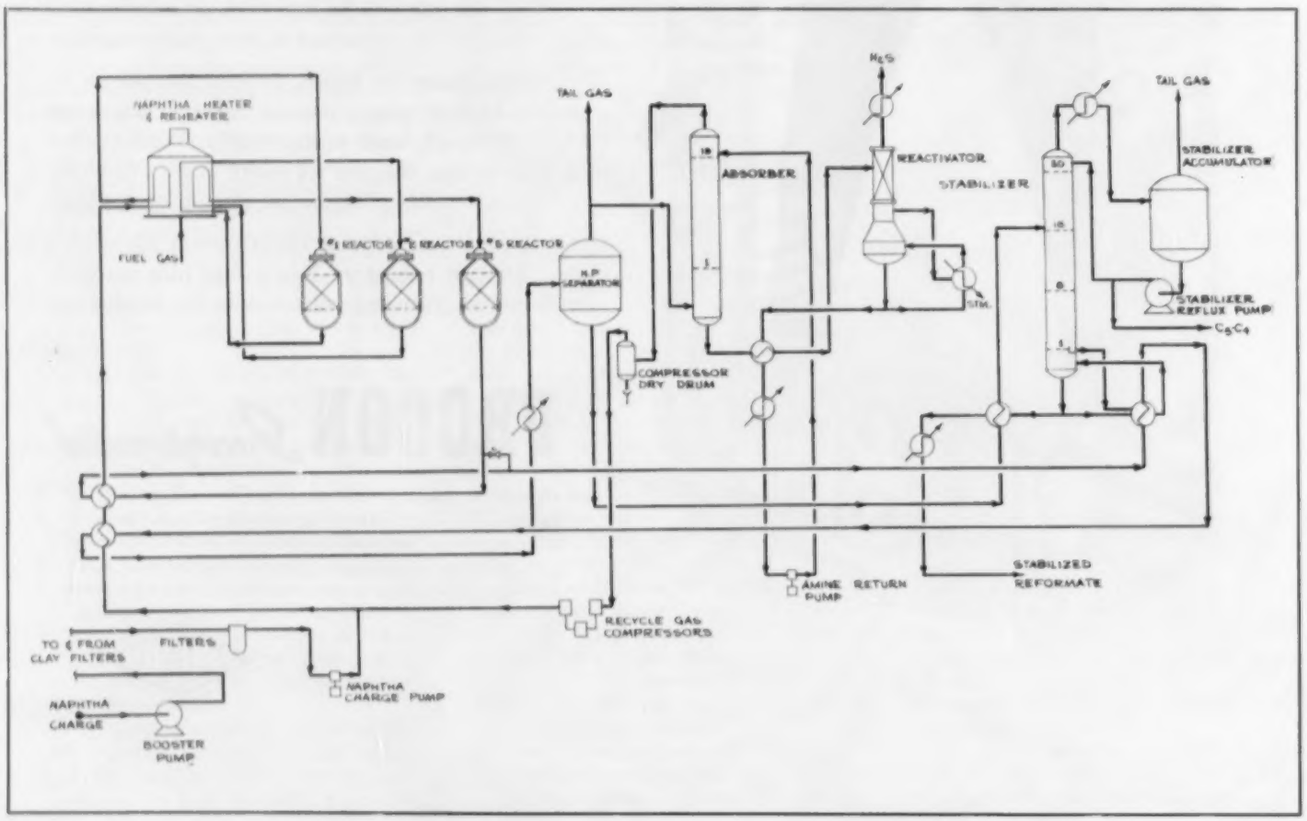
Reflux for the top of the tower is obtained by pumping liquid from the second tray in the fractionator through heat exchangers and back to the top tray of the tower. Heat is removed from this stream by exchange with fresh feed, exchange with the recovery unit debutanizer feed, reboiling the absorber stripper, and finally by a water cooler.

The overhead vapors off the tower are partially condensed, the liquid being sent to the absorber-stripper tower and the vapors to the compressor dry drum. The gas from the drum is compressed by means of a motor-driven centrifugal compressor, then partially condensed and sent to the absorber-stripper feed settler. The vapor and liquid from the settler are fed to the absorber-stripper. Connections have been made to this line so that an extraneous liquid stream from the topping unit, stabilizer and an extraneous vapor-liquid thermal unit stabilizer stream can also be fed to this absorber stripper.

Heavy naphtha from the bottom of a lean oil still is used as sponge oil to recover propane and heavier hydrocarbons which escape from the absorber-stripper. Tail gas from the secondary absorber overhead flows into the refinery fuel system. Bottoms from the absorber-stripper are pumped through heat exchange to the lean oil still.

(*Continued on page* 118)

Flow diagram of the catalytic reformer at the Calgary refinery.



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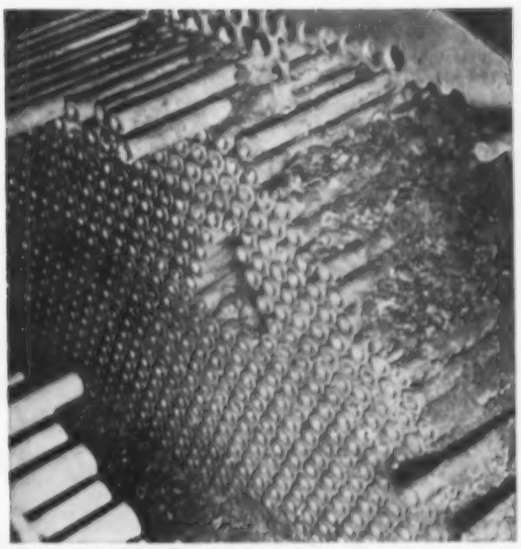

LOST EQUIPMENT—Cross-section view of a condenser bundle knocked out of service by corrosive attack. Polyrad can help prevent such loss.

LOST TIME—This fouled condenser bundle also cost money to clean. Polyrad's detergent action prevents the formation of organic and inorganic deposits, permits their removal in fluid stream.

There's no longer any reason for frequently cleaning or replacing corroded condenser bundles. Now, through Polyrad's chemical control of fouling and corrosion, this common cause of increased operating costs can be eliminated.

A filming amine inhibitor, Polyrad forms a protective molecular shield that controls the corrosive action of organic and inorganic acids. Throughout the refinery, Polyrad helps maintain throughput, increases heat transfer, reduces metal loss, and cuts down time for maintenance. Fouling is prevented by Polyrad's detergent action, which loosens iron sulfide and other scales to permit their removal in the fluid stream.

Polyrad is readily available from stocks maintained throughout the nation. A Hercules technical representative will be glad to help you evaluate what Polyrad can do for you under your specific operating conditions. For additional data, write Hercules.

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FILMING AMINE INHIBITOR

British American

(*Continued from page 116*)

The lean oil still is operated to produce a 250°F end point gasoline and lighter material overhead, and a heavy naphtha bottom stream. The net heavy gasoline product is given a two-stage caustic wash, followed by a water wash. The overhead material is pumped to the debutanizer. The bottoms from the debutanizer is the light gasoline line product which, when caustic and water washed and combined with the treated heavy gasoline, gives the total 7.5# rvp, 400°F end point gasoline product. The overhead product from the debutanizer is pumped through the Girbotol unit for removal of hydrogen sulfide and then to the catalytic polymerization unit.

Catalytic Polymerization Unit: The catalytic polymerization unit is a UOP reactor type using a phosphoric acid catalyst and designed to yield 1,260 b/sd cat poly gasoline. This unit consists of a depropanizer, debutanizer and two sets of reactors connected in parallel, each set containing two reactors in series.

In normal operation, the preheated feed consisting of total C_3s and C_4s is pumped to the reactor system at 1,000 psig and 445°F. The hydrocarbon enters the top of first reactor in each set, passes downflow through the tubes and out the bottom to the top of the second reactor of that set. The effluent from the second reactor is heat exchanged against the cold feed and then passed through a back pressure control valve to the effluent cooler for cooling as feed to the depropanizer. The overhead from this tower in excess of required reflux is cooled and dried and marketed as LPGas. Butane and polymer gasoline are taken as bottoms from the depropanizer and fed to the debutanizer, where the required vapor pressure on the poly gasoline is obtained. The overhead C_4s are used for blending with gasoline for vapor pressure correction.

An alternate operation is to use the depropanizer as a feed splitter. In this case the feed is separated into an overhead C_3 fraction for LPGas and a C_4 fraction which is charged to the reactors. The reactor effluent in this operation is cooled and charged directly into the debutanizer.

Anticipated yields when cracking a 24.7° API gas oil blend, using natural catalyst, 70 percent conversion, a 1.5 TPR and a reactor bed temperature of 900° F are shown below.

	b/sd	Vol. %
Fresh Feed	11,610	100.0
Combined Gasoline	6,324	54.5
Lt. Gas Oil	2,903	25.0
Decanted Oil	581	5.0
Cat. Poly Feed	1,167	10.1
Dry Gas (F.O.E.)	864	7.4
Coke (#/Hr.)	13,500	

An interesting innovation for B-A is the use of induction type electric motor drives on the air blower and gas compressor. Both electric motors were manufactured in Canada by Canadian General Electric. The 4,000 hp motor on the air blower is a three phase, 4,000 volt, 60 cycle squirrel cage induction type motor, with a force-ventilated enclosure, and is the largest motor of its type ever built in Canada by Canadian General Electric. A turbine driven fan ventilates the motor windings. The blower, a three stage centrifugal machine manufactured by DeLaval Inc., is equipped with a 3.1 to 1.0 speed increaser, with a motor speed of 1,200 rpm. The 1,500 hp electric motor for the gas compressor is also a three phase 4,000 volt, 60 cycle, squirrel cage induction motor with a force-ventilated enclosure.

Each motor has its own separate ventilating system. Uncontaminated air is drawn from a point about 20 feet above ground level by a steam turbine driven fan and forced through the motor casing and windings. This ventilating air performs the dual purpose of cooling the motor and pressurizing the motor casing, thus preventing the entrance of combustible vapors.

Each motor has six resistance temperature detector coils embedded in its windings. These six points connect to a strip chart temperature recorder located on the main board in the control room, which continuously records all six temperatures. These temperature points are also tied into the alarm systems in the control room and the compressor room. Abnormal temperatures sound a howler in each location and actuate red alarm lights. In the case of the 4,500 hp motor, the sixth temperature detector coil connects to a temperature relay in the motor starter. This relay will shut down the motor in the event of dangerously high temperature and will not allow it to be restarted for a period of about 20 minutes, thus giving it time to cool down.

Ventilating air pressure is interlocked with the motor starters in such a way that the motors cannot be started until air pressure has been established in the ducts; the motors are also tripped off the line in the event of air pressure falling below a preset value.

The motor starting equipment is C.G.E. "Magnablast" air break type, and is located in a building some 300 feet from the motors in an area classified as non-hazardous.

The 1,500 hp motor is started across the line. The 4,500 hp motor is controlled by a reactor type of starter which provides one step of reduced voltage. The motor starters are interlocked in order that the motors cannot be started simultaneously.

The motors are protected by the following relays:

4,500 hp: instantaneous overcurrent relays; differential relays; phase unbalance relays; temperature relay actuated by RTD embedded in motor windings; and time delay undervoltage relay.

1,500 hp: instantaneous overcurrent relays; thermal overload relays; phase unbalance relays; and time delay undervoltage relay.

The switchhouse which houses the starters also contains two banks of capacitors which are connected to or disconnected from the 4,160 volt bus as the 4,500 hp motor is started or stopped. This switching is accomplished by a separate circuit breaker controlled by auxiliary contacts in the motor starter.

In order to insure continuity of service to this important electric drive, two incoming power lines have been provided for the refinery main sub

(*Continued on page 120*)

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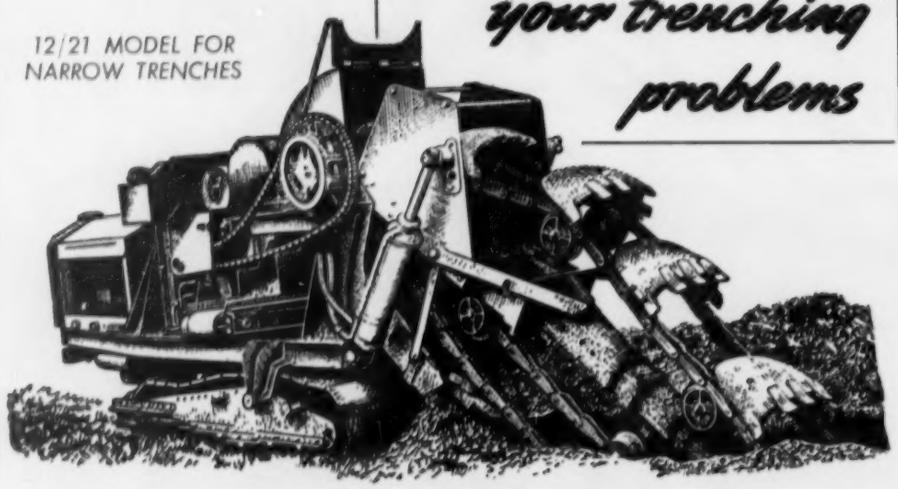

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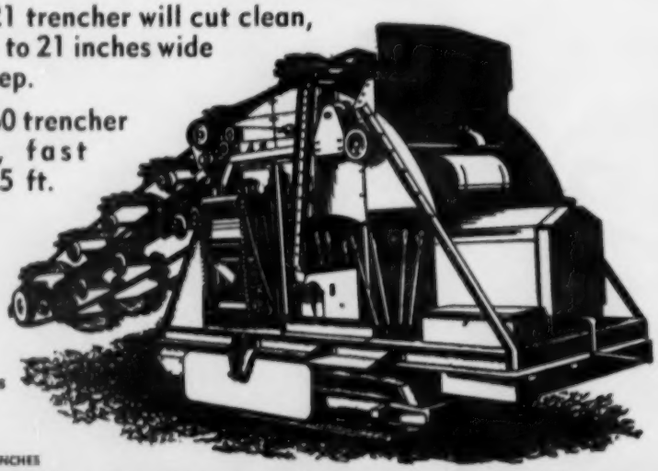

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Mr. Purchasing Director

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YOUR *Occupational Hazard*

● If it hasn't happened to you yet,—it will. Beware!

Some day the company is going to decide to make a new product at your plant. The "market analysis and research" department will assure you the maximum requirement is so many thousand gallons a week. You'll design the plant . . . buy the equipment . . . get on stream . . . and then two or three months later — BOOM!

The market analysis boys "played it safe". Now — based on "newly available statistics" — they need 20% to 30% more output than the plant you just finished can possibly produce.

If you equipped that plant with "bundle" type exchangers you are going to have to wait, while you design — and fabricate — and install all new units. *And,* what are you going to do with the exchangers you just bought? Throw them away after only two or three months use?

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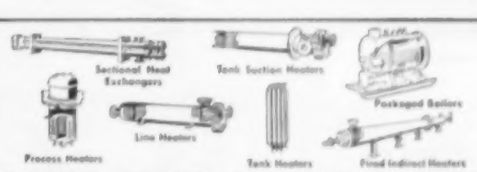

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British American

(Continued from page 118)

station. Each line is provided with reclosure breakers timed at 40 cycles in the Hydro Electric Commission transformer station. The refinery sub station is equipped with automatic throw-over switchgear which is timed to "ride over" the Hydro Electric Power Commission reclosure time. The 4,500 hp motor undervoltage relay has a time setting slightly larger than the throw-over relay, in order that the motor will not trip off during the throw-over period.

The unit is self-sufficient as to steam requirements. The three steam boilers, two on the fractionator and the third on the flue gas stack, produce 55,000 #/hr. of 175 psig steam which is superheated 100°F in the feed preheater furnace. All the steam turbine drivers on the pumps exhaust to 45 psig and this steam is used for catalyst hydration and stripping in the spent cat stripper and fractionator. Since no extra steam generating capacity was added to the refinery boiler house, the steam producing vessels in the catalytic cracking unit have been arranged so that, during startup, steam can be made by circulating gas oil from the feed preheating furnace through the boilers and back to the fractionator.

A new water circulating system was installed for the cat unit. This system discharges the water from all tubular coolers and condensers under slight pressure to a modified API separator. The bottom of this separator is almost at grade level due to the cost of excavating the bedrock which is close to ground level at this point. The separator is made up of three compartments in parallel fitted with the necessary weirs, skimmers, etc. The discharge is directly to the lake. This water is normally free of oil, but an emergency separator is required in the event of a leaking cooler or condenser. In addition to the cat unit cooling water, some normally oil-free streams from the other refinery units have been diverted to this new system, so that oily water from the cat unit can be handled in the old separators.

As part of an overall program for the reduction of phenols and other compounds in the waste water discharged from the refinery, certain phenol-containing waste waters from reflux drums in the cat unit are sprayed into the flue gas vent stack for disposal.

All relief and overpressure control valves discharge to a smoke controlling flare designed from a similar installation at the General Petroleum Corp. refinery at Torrance, Calif. The main feature of this installation is the use of venturi burners so that excess air is drawn in to eliminate or minimize smoke.

Calgary Catalytic Reformer: The Calgary refinery, with topping and thermal cracking facilities only, for some time has been finding it difficult to produce gasolines of the required octane level with a reasonable quantity of TEL. It was therefore decided to install a catalytic reforming unit to upgrade the straight run naphthas. The Fluor Corp. of Canada Ltd. was awarded the contract to engineer and construct such a unit of the type licensed by the Atlantic Refining Co. This Catformer went on stream in February of this year.

The Catformer, together with the stabilizer section and amine treating unit, is designed to process 2,000 b/sd of total straight run gasoline from a mixture of light and heavy Western Canadian crude oils. This straight run naphtha has a final boiling point of 380-400°F with research octane of 53.4 clear and 70.8 with 3.6 cc TEL per imperial gallon. At present, the Catformate produced has a research octane of 80 clear. Provision has also been made to process up to 25 percent of a thermal naphtha.

The process consists of contacting naphtha vapors with a platinum catalyst in three fixed bed reactors in the presence of a high partial pressure of hydrogen. The various hydrocarbons found in straight run naphtha are converted to other hydrocarbons in such a manner that the octane of the product is much higher than that of the feed material. While the catalyst is quite rugged, care must be exercised to prevent entrained solids and contaminants from treating steps (such as TEL) from entering the reactors. The life of the catalyst can be extended by a simple in-place regeneration. Carbon is burned off with a dilute air-in-steam mixture.

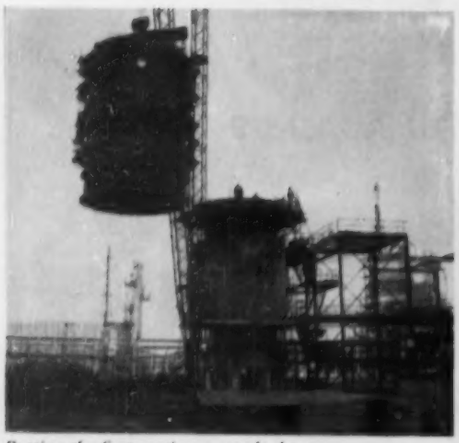
Description of Flow: Naphtha from tankage is pumped through a filter to remove solids and then to a feed preheat exchanger. Recycle gas, rich in hydrogen, joins the naphtha before entering the exchangers where heat is picked up from the effluent of the last reactor. The mix is further heated in the primary heater to bring it up to a reaction temperature of about 850-900°F and then flows downward through the first bed of catalyst. As the naphtha is upgraded, the temperature of the flowing stream decreases, because the reforming reaction is endothermic. The stream must be heated to reaction temperature again by passing it through a second heater. It then is passed through the second reactor from which it is conducted through a third heater and finally through a third catalytic reactor. From the final reactor, the effluent flows to exchange where it preheats the cold feed and reboils the stabilizer, followed by a water cooler before entering the flash drum.

The liquid product is separated from the recycle and make gas in a high pressure separator. Most of the hydrogen-rich gas flows upward through an amine absorber to remove H_2S before it is recycled by the hydrogen compressors back to join the feed ahead of the exchangers. A knockout drum follows the absorber column to protect the compressors from liquid carry-over. The excess gas from the high pressure separator is released under pressure control to the Catformer tail gas line and to the reformer and refinery fuel gas system. Hydrogen is continuously produced by the reforming reactions, and therefore no hydrogen is required from external sources except during start-up periods.

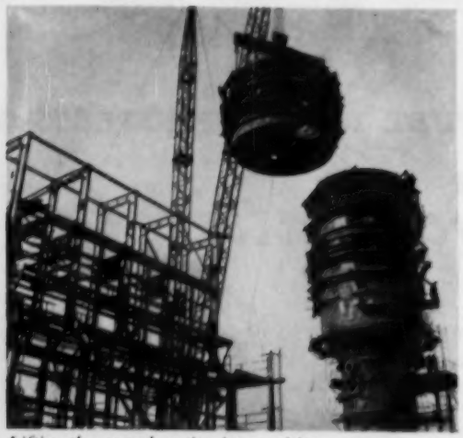
Liquid is released from the high pressure flash separator on level control to a conventional stabilizer column where light hydrocarbons are removed to produce a motor gasoline of the desired RVP. The overhead from the stabilizer is condensed and flows to an accumulator. A portion of the liquid is returned to the stabilizer as reflux, while the re-

(Continued on page 122)

The new vacuum pipestill unit at Fawley

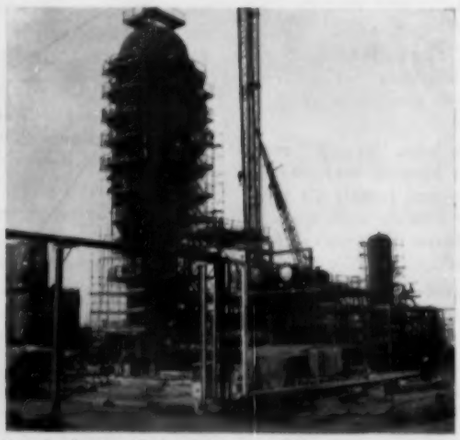


Putting the first section on to the base



Lifting the second section into position

Preparing to raise the domed head



The final assembly in progress

Recent further installation work by Messrs. Foster Wheeler Limited at the Esso Petroleum Company's new gigantic refinery at Fawley, Hants, includes this 95-foot tower of stainless clad steel fabricated to the stringent API ASME Code and subjected to spot x-ray examination, all connections being Magnaflux tested.

In all this work Fleetweld 5 and Multiweld electrodes, with Lincoln machines, were used exclusively.

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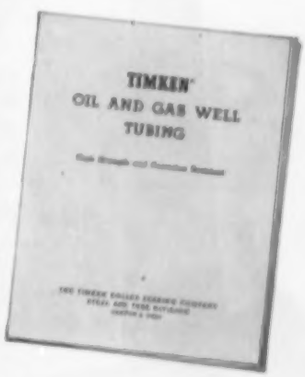


YEARS AHEAD—THROUGH EXPERIENCE AND RESEARCH

SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS TUBING

British American

(*Continued from page 120*)

mainder on level control goes to existing units for alkylate production from the isobutane content. The uncondensed portion of the stabilizer overhead is released into the fuel gas system from the Catformer tail gas line under pressure control. Heat is supplied for the column in a reboiler by the effluent from the third reactor. The stabilized Catformate is exchanged with the stabilizer feed and water cooled before going to tankage.

A high partial pressure of hydrogen is required to depress the formation of carbon on the catalyst, and it is necessary to charge the system initially from an outside source of hydrogen. The process is operated at a pressure of from 500-700 psig, and to maintain the required partial pressure a minimum recycle flow of 10 mols of recycle gas for each mol of naphtha is necessary. The effect of sulfur on the catalyst is to reduce reformate octane at a given product yield. Hence, to minimize the quantity of sulfur contacting the catalyst, the recycle gas is treated in the amine absorber to reduce H_2S content to less than 10 grains per 100 cubic feet.

The absorbing medium in the hydrogen sulfide absorber is monoethanolamine. Aqueous amine solution is circulated through the absorber where it counter-currently scrubs the hydrogen sulfide from the recycle gas. The spent amine flows to the reactivator where hydrogen sulfide is stripped from the solution in a conventional tower. A steam heated reboiler supplies heat to the tower.

The effectiveness of hydrogen to prevent coke formation increases with pressure. For normal straight run naphtha stocks of 360°F end point, the most economical operating pressure is 500 psig. With heavier naphthas up to 410 ep, longer catalyst life is obtained by operating at 700 psig. This increase in pressure causes a slight drop in octane at a given yield, but the increase in catalyst life will more than compensate for the decline in yield octane.

As the run progresses, the activity of the catalyst tends to decline as carbon gradually accumulates and other chemical and physical changes take place. An increase in temperature, however, compensates for this change in activity of the catalyst. This unit is designed so that the reactor inlet temperature may be increased to a maximum of 975°F to maintain reforming severity. When this temperature is reached or an operating upset results in heavy coke laydown, regeneration in place is used to restore catalyst activity. It eventually, however, becomes necessary to replace the catalyst.

This unit is also capable of reforming up to 25 percent of a thermal naphtha in the total feed.

	Feed	Debut. Reformate
API Gravity	52.5	46.2
RVP	2.9	5.2
Wt. % Sulfur	0.13	.001
ASTM Dist.		
IBP	126	124
10	186	168
50	297	275
90	366	352
FBP	406	424
Research Octane Clear	56.6	89.5
plus 3.6 cc	—	97.6

Description of Equipment: The heaters mentioned previously are actually separate coils contained in a single Petrochem furnace divided into pie-shaped segments by firebrick walls for a distance of six feet above the burner levels. There are two gas-fired burners in each of the first two coils and one in the third for heat absorption of 6.6, 5.37 and 1.6 Btu hr. respectively. They are adapted to utilize the reformer tail gas which is 92 percent H_2.

The three reactors in this unit are cylindrical shells five feet six inches in height and 54 inches I.D. with conical upper and lower heads. Insulation reduces the effective I.D. to 45 inches. The interior lining of the reactors is 16 gage type 405 stainless steel. The catalyst is five feet in height bounded on the top by six mesh wire. Above this screening, ⅛ and ¾ inch alundum balls are spread to a depth of three inches and act as a diffusing medium to prevent channelling. The catalyst bed is supported at the bottom by a similar three inch layer of alundum balls. The total catalyst charge in the reactors is 7,200 lbs., and at the design rate of 2,000 b/sd will give a space velocity of 3.0, i.e. 3 lb/hr. naphtha per lb. of catalyst.

The two recycle gas compressors are driven by 165 hp gas engines using purchased gas as fuel. As mentioned previously, outside hydrogen is required only for start-up, as during operations a surplus over that required for recycle and fuel gas is available. After the initial start-up, when hydrogen must be purchased, provision has been made to store some of this surplus hydrogen for subsequent start-ups.

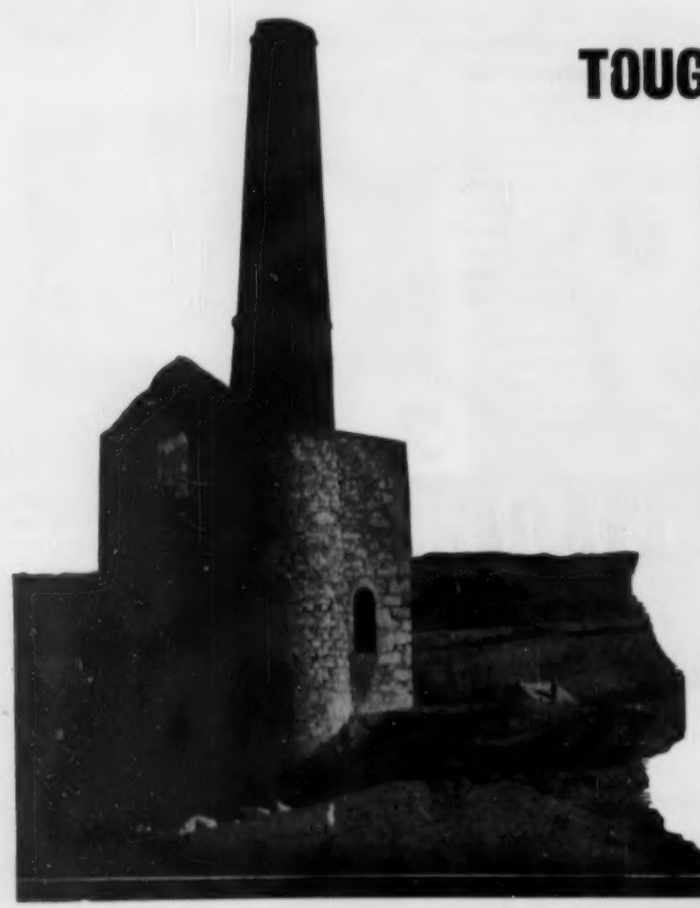
Hydrogen Storage: Due to the distances and subsequent high shipping charge involved in obtaining start-up hydrogen at the Calgary refinery, it was decided that this material should be stored as produced and thence readily available for emergency use. The quantities involved are not extensive, but must be sufficient for two pressurings of the system since it is possible that the first charge after a start-up may be lost due to leakage or equipment failure.

The section of the unit which must be pressured prior to naphtha charge has a volume of 544 cubic feet. This means that to pressure this to 200 psig requires a supply of 7,850 scf, or a minimum storage of 16,000 scf for two starts.

A surplus Cross reactor, a single Krupp forging 44 feet long by five feet diameter by 4 inches thick, was available for hydrogen storage. This vessel was approved by the Province of Alberta Department of Labor for use at 1,200 psig at 100°F, and therefore suited our purpose. The storage capacity is 25,740 scf and maximum unit discharge pressure is 700 psig.

The nozzles on the surplus vessel were of the screwed hub type. These were removed and a flat area 12 inches in diameter was faced around each opening. New nozzles were attached by tapping 1¼ inch studs into the vessel wall and bolting on four inch 900 lb. flanges. Of the four original openings, two were blanked in the final assembly while the

(*Continued on page 124*)



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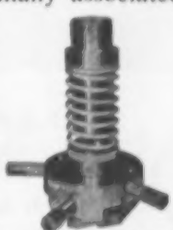

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(*Continued from page 122*)

other two on the top, one near each end, were equipped with weld neck flanges and reducers to two inches. One nozzle is used for a 2 by 3 relief valve and the other for a two inch filling and discharge line. As a final safety precaution, the vessel was inspected throughout, the seams X-xayed and the end flanges machined to ensure a tight fit.

Montreal Catalytic Reformer: Another step toward marketing higher octane gasolines in Eastern Canada has been initiated by B-A at the Montreal East refinery. The Lummus Co. Canada Ltd. has been awarded the contract to engineer and construct an Atlantic type catalytic reformer designed for a reactor charge of 13,000 b/sd of a 175-370° boiling range naphtha. The installation will also include a prefractionation section to prepare the reactor feed from a full range 360 ep naphtha. This full range naphtha would amount to 15,550 b/sd obtained from medium gravity Eastern Venezuelan crudes.

The unit has been designed to give a yield of 88.9 volume percent of the reactor charge when a 90 F-1 clear octane number reformate is produced. This operation can be carried out with three reactors. If a 95 octane number reformate is required, provision has been made to add another heater and reactor.

Description of Flow: The full range naphtha is pumped from storage through heat exchange to the prefractionator where an overhead of C_6-and lighter is taken off and pumped to storage for gasoline blending. The bottoms from the prefractionator is the charge to the reactors. This material along with recycle gas is heated by exchange, and a convection and radiant heating coil to a maximum 975°F and at a pressure of 500 psig is pumped through the first reactor. Due to the endothermic reaction, a further heating in a coil is required before going to the second reactor and this sequence is followed before the third reactor. The effluent from the final reactor is cooled by exchange with the incoming feed and by reboiler duty. By means of a flash drum and knockout drum, the hydrogen-rich gas is separated from the reformate and recycled to the process. The bottoms from the flash drum is pumped to the stabilizer for vapor pressure control and then to Catformate storage. The overhead C_6-C_7 cut will be further processed in an existing cat poly plant. To minimize carbon deposition on the catalyst, a high partial pressure of hydrogen is required. This is obtained by recycling 10 mols H_2 to one mol reactor charge. This Atlantic process allows in-place regeneration to prolong catalyst life.

Fuel gas for use in the unit itself and any excess which is released to the refinery system is yielded from the prefractionator reflux accumulator, stabilizer reflux accumulator and knockout drum.

Due to the low sulfur content of the present charging stock, an H_2S absorber has been provided for the recycle gas. In the event that stocks with higher sulfur content may be encountered in the future, arrangements have been made to install ahead of the prefractionator a heater and a desulfurizer reactor through which the feed and recycle gas are desulfurized.

Equipment: The coils for heating the charges to the reactors are contained in a Lummus type horizontal tube heater for hydrocarbon vapor heating service. It is composed of three horizontal tube radiant chambers and an overhead convection section. The combustion chambers are fired vertically from the hearth by means of several fuel gas burners designed to burn tail gas from the reforming unit. The duty in MM Btu/hr. of the convection section is 23 and in the three radiant sections are 32.5, 21.7 and 10.9 respectively.

The original design of the reforming unit calls for three reactors, each of which is a 10 foot I.D. sphere, with a liner of 16 gage stainless steel. The catalyst bed is five feet in height bounded on the top and bottom by six mesh screen as a support. On either side of the screen, six inches of inert balls are closely packed to assist in dispersing the stock. At the inlet of the sphere a 23-inch diameter deflector is provided for the same purpose. After the material passes through the catalyst bed, a grid of collector pipes slotted and wrapped in six mesh screen conduct the effluent to the outlet of the sphere.

The total catalyst charge in the reactors is 48,000 lbs., which at the design rate of 13,000 b/sd gives a space velocity of 3.0.

The three recycle gas compressors are powered by 800 hp gas engines using as fuel the off-gas from the stabilizer reflux accumulator. For start-up, LPGas is used after vaporizing in a propane vaporizer. Facilities for storage of hydrogen are being provided in order to have a supply for start-ups. The hydrogen for the initial start-up must be purchased, however.

Offsite facilities to be provided for at this time include:

1) Relocation and changes in one of the refinery flare stacks.

2) A cooling tower and water pumping facilities to circulate 3,900 US gpm.

3) Electrical substation facilities.

General: The installations of the Orthoflow catalytic cracking unit at Clarkson refinery and the catalytic reformers at Calgary and Montreal East refineries are the highlights of a program being carried forward in all B-A refineries for the utilization of the most effective treating methods to ensure the marketing of products of the highest quality.

Robinson Appointed Clark Sales Manager

Roger W. Robinson has been appointed sales manager for Clark Equipment Company's transmission division, it is announced by C. H. King, Clark vice president.

Mr. Robinson will make his headquarters at the company's transmission plant in Jackson, Mich. and will be responsible for sales of the complete list of Clark transmission, torque converters and power train packaged units. With the company since 1941, he was previously company representative handling transmission and axle sales.

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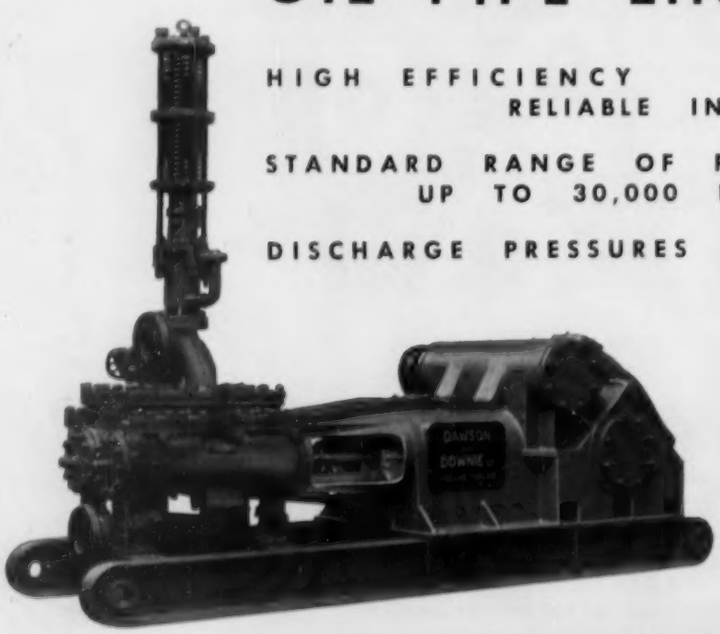

Illustration shows one of a series of pumps supplied to ANGLO-IRANIAN OIL CO's refinery at ADEN, for pumping diesel and fuel oils from the refinery to the B.P. bunkering installation.

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The fleet of 'Pyrene' Mobile Foam Tenders, and (extreme right) a typical storage tank installation incorporating a 'Pyrene' Foam Riser terminating in a Vapour Seal Box, at the Esso Petroleum Company's Refinery, Fawley, England.

Trends in petroleum refining products

By Felix Heinemann and Heinz Heinemann

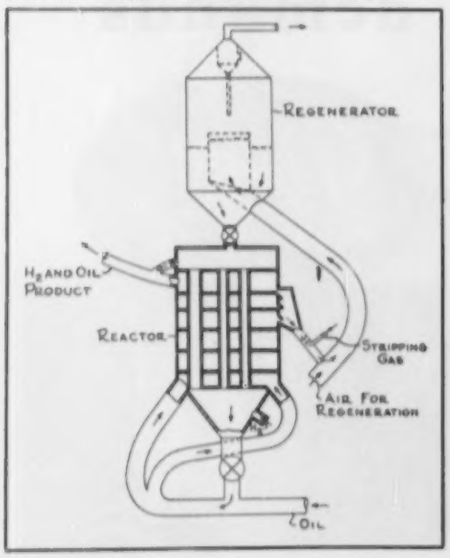
THIS IS THE THIRD annual review of petroleum refining patents published in WORLD PETROLEUM. It covers patents issued in the United States from May 1954 through April 1955. Like its predecessors, it cannot make a claim to completeness in view of the very large number of patents dealing with petroleum refining subjects. In order to attempt to show at least the lines of emphasis of recent research and development efforts in the industry, this review has been limited to seven major fields of interest. Space limitations do not permit consideration of some other subjects such as hydrocarbon synthesis, lube oil refining, waxes and additives. Several patent reviews on petrochemicals have appeared in WORLD PETROLEUM during the past year and this large and important area has therefore not been treated in the present article. It is hoped that some of the developments not discussed in this issue can be covered separately during the next year.

Catalytic Reforming and Dehydrogenation

This subject was last reviewed in the January 1955 issue of WORLD PETROLEUM. Since then a considerable number of patents have issued, indicative of the importance of the field and the widespread efforts of the industry's laboratories to exploit it.

Esso Research and Engineering Co. has obtained a group of patents on fluid hydroforming. In 2,696,460 C. E. Hemminger fractionates virgin naphtha into a light fraction which is subjected to hydroforming and into a heavier fraction which is thermally cracked or reformed and then hydrogenated. The hydrogenation and catalytic reforming steps are carried out simultaneously in the same zone over the same catalyst to obtain a heat balance. An apparatus for reforming hydrocarbons is described by F. H. Blanding in 2,701,230 (see Figure 1). It is operated isothermally or with an upward temperature grading. The hydrocarbon-catalyst mixture is passed upward in a fluidized bed. Withdrawn catalyst is regenerated and hot regenerated catalyst passed downward in indirect heat exchange with hydrocarbons. J. Weikart in 2,700,639 regenerates a stream of catalyst and mixes it while hot with a second stream of withdrawn non-regenerated catalyst. The mixture is treated with hydrogen and returned to the reactor. The temperature of the regenerated catalyst is lowered by the second stream and heat of regeneration is transferred to more catalyst prior to introduction into the reaction zone. D. D. MacLaren in 2,694,672 discloses a method of stripping reforming catalyst in a fluidized bed.

Fig. 1: U. S. Patent No. 2,701,230. Hydroforming process and apparatus, by F. H. Blanding.



Houdry Process Corp. patent 2,700,013 (A. G. Oblad, T. H. Milliken and H. Heinemann) is concerned with the reforming of thermally cracked and other gasolines with a siliceous catalyst comprising at least 70 percent silica and containing 0.2-2 percent molybdena. The exact amount of molybdena employed is a function of the cracking activity of the catalyst. H. G. McGrath in 2,695,866 (to M. W. Kellogg Co.) reforms naphthas over a catalyst selected from the group consisting of oxides of chromium and molybdenum. Naphtha to catalyst ratios below 7, temperatures of 750-1150° F. and partial pressures of hydrogen of at least 50 psi are employed.

The conversion of hydrocarbons containing alkylcyclopentyl groups to aromatics over platinum catalysts at 275-400° C. and in the presence of an alkyl chloride is disclosed in Universal Oil Products Co.'s 2,706,208 (H. Pines and V. N. Ipatieff). In the same company's patent 2,697,681 M. J. Murray and V. Haensel claim a combination process of deasphalting and hydrocracking reduced crudes using reformer hydrogen. Hydrocracked gasoline is reformed to give more hydrogen.

A catalyst for dehydrogenating C_2—C_5 paraffin hydrocarbons at 700-1,250° F. is discussed by R. P. Sieg and H. B. Wellman in California Research Corp.'s 2,706,741. This catalyst consists of 77 percent alumina or alumina-silica, 15-20 percent of an oxide of a metal of group VI and 8 percent beryllia.

Selective hydrogenation of diolefins in a cracked naphtha is the subject of 2,694,671 (P. K. Baumgarten, E. J. Hoffman and E. F. Wadley to Standard Oil Dev. Co.). A nickel-tungsten sulfide catalyst is employed at 500-600° F., 15-500 psig and a 3-12 space rate.

Catalytic and Thermal Cracking of Hydrocarbons

This subject continues as one of the most active in the field of hydrocarbon conversion patents. The number of patents which have issued since it was last discussed in the 1954 Annual Review number of WORLD PETROLEUM is so large that it is impossible to discuss more than a few within the frame of the current article. A more detailed review of this subject is planned for the near future.

Catalytic cracking patents can be subdivided into those dealing with moving bed and those with fluidized bed processes. Houdry Process Corp., Socony-Mobil Oil Co. and Union Oil Co. of Calif. are the assignees of most of the patents in the first group. Among the Houdry Process Corp. patents, 2,701,232 (R. Kollgaard) proposes contacting hydrocarbons in liquid phase with a hot solid granular catalytic mass at suitable temperature in an area provided above a compact bed of such mass within a solids supply zone communicating with the inlet to a vapor lift system. Liquid hydrocarbons are transformed to vapors which are used to move the granular mass into and transport it upwardly through the lift to a discharge zone. G. D. Myers in 2,694,036 employs as lift gas a mixture of steam and flue gas from the lower portion of the regeneration zone. A. G. Oblad and G. A. Mills (2,704,740) describe a method of reducing the rate of attrition of make-up catalyst by avoiding thermal shock of new catalyst containing moisture. The make-up catalyst is contacted with a flowing stream of hot inert gas at below 300° F. to effect moisture removal prior to introduction into the moving bed system. In the group of Socony patents, 2,684,927 (E. V. Bergstrom) discloses gravitating a solid column of catalyst through reaction and regenerating zones. The catalyst then enters a stream of lift gas and is sucked upwards to a separation zone maintained under a vacuum sufficient to accomplish the lifting. R. D. Drew (2,705,216) proposes a method of contacting solids with reactants in a moving bed, while methods of catalyst transportation are disclosed in 2,697,685 (F. C. Fahnestock, J. P. Shambaugh and J. C. Howard) and 2,687,371-372 (V. O. Bowles and F. E. Ray). Catalyst added as make-up to the system has, according to C. H. Lechthaler (2,701,785), a conversion activity not substantially greater than the activity of the bulk of the catalyst at the time of addition. R. D. Drew and M. B. Tohline (2,695,266) describe the removal of combustible vapors from a catalyst prior to its regeneration. Six Union Oil Co. of California patents (2,684,928-932 and 2,695,212; C. O. Berg) concern a dense phase lift system and its operation. Flow through the system is controlled by alternately pressurizing and depressurizing an intermediate conveyance zone.

Patents on fluidized bed cracking are assigned to a larger number of companies. J. W. Jewell (2,686,710 to the M. W. Kellogg Co.) claims improvements in fluid bed operation consisting of a lower dense phase and an upper dilute phase of lower solids concentration. A confined stream of solids suspended in gases is introduced into the reaction zone above the surface of the dense phase and deflected downwardly onto an upper surface of the dense phase. Other methods of operating a fluidized bed are described by C. A. Rehbein (2,700,641 to Shell Dev. Co.) and J. W. Beam (2,688,588 to Deep Rock Oil Corp.). P. C. Keith (2,702,267 to Hydrocarbon Research, Inc.) established a third fluidized zone between reaction and regeneration zones, in which fouled catalyst is stripped with regeneration gases containing hydrogen. F. A. W. Leffer (2,689,210 to Universal Oil Products Co.) carries out the reaction in tubular reaction zones, eliminating the need for large diameter chambers. C. E. Starr (2,701,231 to Standard Oil Dev. Co.) provides a method for starting up fluid catalytic cracking units for feed stocks high in aromatics. Catalyst regeneration temperatures must be above 1100° F. to burn coke laid down from aromatics. These temperatures are initially obtained by using a special start up feed stock containing at least 40 percent aromatics, at least 10 percent of which have fused rings.

A method of cracking high molecular weight hydrocarbons is described by W. A. Pardee and G. E. Elliott (2,706,168 to Gulf Research & Dev. Co.). A magnesia-calcium oxide-silica composite catalyst is used. C. N. Kimberlin, Jr. and E. M. Gladrow (2,694,673 to Standard Oil Dev. Co.) employ a silica-alumina catalyst for the cracking of naphthenic-paraffinic hydrocarbons. Naphthenes are preferentially cracked with 600-100 Å average pore diameter catalyst paraffins with 20-40 Å average pore diameter. R. K. Stratford and B. H. MacKenzie (2,687,988 to Standard Oil Dev. Co.) disclose a method for regenerating spent catalyst from a suspensoid operation. Entrained cracking catalyst can be removed from oil in a fractionation column according to Phillips Petroleum Co.'s 2,689,209 (A. H. Blair).

Coking of heavy hydrocarbons has been a very active subject during the past year, spearheaded by patents on Standard Oil Dev. Co.'s fluid coking process. C. E. Adams in 2,698,284 intimately mixes the residual feed with water and sprays the mixture into a fluidized bed of solids at a temperature and pressure to cause instantaneous vaporization of the water. Good dispersion of the residuum is obtained. J. W. Mattox in 2,700,642 contacts residual oils at coking temperature with a fluidized mass of metallic carrier solids. Coked solids are subjected to thermal shock to splinter off coke particles. J. W. Brown (2,700,017) cokes residues in a dense fluidized bed at 800-1100° F. Coke particles are partially combusted to raise their temperature to 1,100-1,400° F. They are then returned to the coking zone. A. Voorhies, Jr. (2,685,551) obtains increased yields of motor fuel by coking residues on hot, fluidized inert solids containing 1-10 percent finely subdivided cracking catalyst. C. E. Adams, C. N. Kimberlin, Jr. and W. J. Mattox (2,690,990-991) describe a two stage process in which cracking is carried out first at mild, then at more severe conditions. The accompanying graph (Figure 2) shows the break in yield obtainable at temperatures above and below 950° F.

A fluidized bed process for coking heavy hydrocarbons is the subject of Universal Oil Products Co. patent 2,687,992 (F. W. Leffer), while 2,697,069 (J. M. Bradley to G. L. Cabot, Inc.) describes an

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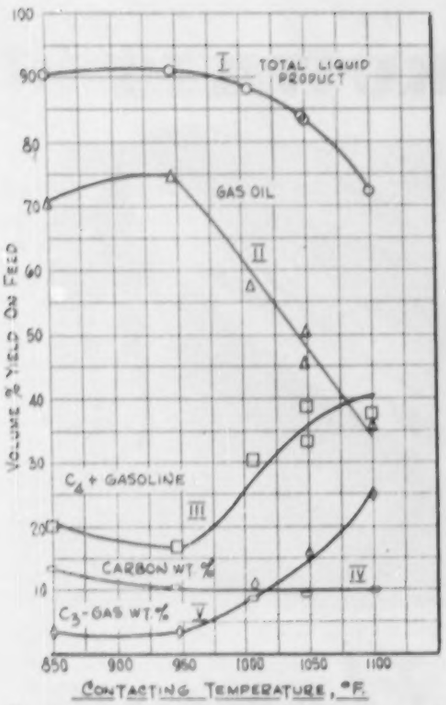


Fig. 2: U. S. Patent No. 2,690,990. Production of motor fuels from heavy hydrocarbon oils in a two stage conversion process with inert solids, by C. E. Adams, C. N. Kimberlin and W. J. Mattox.

apparatus for coking liquid hydrocarbons. A continuous moving bed coking unit and methods of its operation are disclosed in 2,701,788 (A. H. Schutte to the Lummus Co.). Two Standard Oil Dev. Co. patents dealing with vis-breaking. J. M. Jennings and G. F. Pappas (2,687,986) operate a two-stage unit with tar residue from the first stage being charged together with virgin feed to the second stage. W. O. Taff, J. Weikart and R. W. Eustis (2,695,264) claim improvements in vis-breaking operation by reducing temperature and residence time of tar in the separation zone.

A combination of thermal cracking with a hydrocarbon synthesis process is described in Texas Co.'s 2,698,782 (C. A. Coghlan). F. J. Jenny (2,698,830 to Texaco Dev. Co.) supplies the thermal energy and the physical medium for cracking a relatively low carbon residue fraction by burning a relatively high carbon residue fraction with pure oxygen to form hydrogen and CO.

Pebble heaters, their operation and their use in the thermal cracking of hydrocarbons are the subject of a group of Phillips Petroleum Co. patents. Design and methods of operation are described in 2,692,903 (K. H. Hachmuth) and 2,694,096 (H. J. Hepp). C. F. Bethea (2,685,560) proposes a method of sealing the reaction chamber from the pebble heater chamber by introducing preheated gaseous hydrocarbons or hydrogen into a connecting pebble conduit or by burning a small proportion of the material in the presence of a quantity of oxygen or air less than stoichiometrically sufficient for complete combustion. R. A. Findlay (2,689,211) discloses a procedure of cracking residual oils at high temperatures while avoiding the formation of tar mists.

Hydrocracking and Destructive Hydrogenation

With the greater availability of cheap reformer hydrogen in many refineries, the hydrogenative upgrading of heavy oils seems to gain again in interest and several new patents have issued even since the discussion of this subject in the January 1955 issue of World Petroleum.

In a continuation of earlier patents, Gulf Research & Development Co.'s 2,700,014 (V. J. Anhorn and C. W. Montgomery) deals with the conversion of a hydrocarbon mixture containing difficultly vaporizable components. Contacting of the mixture with hydrogen and a catalyst is carried out at 750-950° F., 250-2,000 psig, while the difficultly vaporizable components are in liquid phase. The liquid hydrocarbons are adsorbed on fluidized catalyst particles and converted to lower boiling hydrocarbons which are desorbed. W. Dettinger and co-workers in 2,706,705 (to Badische Anilin und Soda Fabrik) pass mineral or shale oil through a first reaction zone in liquid phase at 450-550° C. and 200-800 atm. pressure in the presence of hydrogen and hydrogenation catalyst to produce at least 30 percent middle oil boiling between 180-350° C. The total product is then passed with hydrogen in the gas phase over an acid activated carrier containing a small amount of molybdenum or tungsten compounds.

A method of producing large yields of high octane number gasoline from topped crude by a combination hydrocracking and reforming process with internal recycling of fractions is discussed in Houdry Process Corp. patent 2,703,308 (A. G. Oblad and H. Heinemann). J. I. Harper and M. W. Luther (2,706,167 to Sun Oil Co.) describe a method of hydrogenating which is illustrated in Figure 3. Charge oil is fed in liquid phase into a contacting zone containing a hydrogenation catalyst. Hydrogen gas is introduced into the lower part of the zone in an amount in excess of that required for the reaction and at a rate at which the catalyst is maintained in a state of hindered settlement in the oil. The catalyst-oil mixture flows upwards into an enlarged separation zone.

Desulfurization

Hydrodesulfurization and hydrotreating has been described as the fastest growing new processing method in the petroleum industry. This is reflected in an ever increasing volume of patents issuing on this subject. Many hydrodesulfurization patents were reviewed in the January 1955 issue of World Petroleum. Some of the patents since then and patents on other desulfurization methods issued during the past year have been considered for this section.

Two British Petroleum Co. patents, authored by F. W. B. Porter (2,697,682 and 2,706,703) deal with details of the Autofining process. The reaction is carried out over a sulfur stable catalyst in liquid phase in the absence of external hydrogen or hydrogen recycle. Hydrogen is produced by naphthene dehydrogenation. At least three reactors are employed, all but one of which are on stream, while one is undergoing regeneration. A. Voorhies (2,703,780 to Esso Res. & Eng. Co.) proposes to remove sulfur from organic compounds containing at least 0.23 wt. percent combined sulfur by direct hydrogen transfer from naphthenes over an activated carbon catalyst at 650-950° F. Between 3 and 15 moles of naphthene are charged per mole of sulfur compound. A process arrangement for the hydrodesulfurization of heavy hydrocarbons at 250-2,000 psig is described by T. P. Joyce in 2,700,015 (to Gulf Research & Dev. Co.). K. M. Brown (2,697,064 to Universal Oil Products Co.) discloses a combination desulfurization and reforming process in which reformer hydrogen is used for desulfurization and hydrogen sulfide in the effluent is reacted with sulfur dioxide over an oxidation catalyst to form elemental sulfur, part of which is burned to sulfur dioxide.

Sweetening of hydrocarbon distillates is the subject of numerous patents. E. P. Goodman and G. E. Thompson (2,690,419 to Standard Oil Dev. Co.) treat a hydrogen sulfide-free sour oil with alkali metal plumbite solution. A. J. Brandel (2,684,926 to California Research Corp.) prevents emulsion formation in a lead sulfide sweetening process by incorporating into the treating agent a minor proportion of sodium sulfonate prepared by sulfonating a fraction of a sulfur dioxide extract of kerosine boiling in the 400-530° F. range. According to Texas Co.'s 2,674,566 (J. C. D. Osterhout and G. D. Pingrey) oil is contacted with an organic metal salt and a mercapto-alkyl-benzimidazole to remove mercaptan sulfur. J. H. Krause (2,695,263 to Standard Oil Co. of Ind.) sweetens cracked naphthas by treatment with a granular catalyst, comprising cupric chloride, water and a carrier. The carrier consists of 60-80 per cent of non-adsorbent material, such as pumice and diatomaceous earth, and 40-20 per cent of adsorbent material.

Another group of patents discusses extraction of sulfur compounds. C. F. Gerald (2,689,207 to Universal Oil Products Co.) countercurrently contacts hydrocarbons with an HF containing liquid at 50-250° F. and in liquid phase. The extract phase is hydrogenated and hydrogen sulfide separated from it. The resulting sulfur-free liquid is passed into countercurrent contact with the hydrocarbon fraction as the HF containing liquid. According to A. P. Lien and H. Shalit (2,677,648 to Standard Oil Co. of Ind.), high sulfur naphtha is contacted with HF at −60 to +30° F. to obtain a small volume of sulfur rich extract. The raffinate is treated with HF activated alumina at 600-900° F. to further desulfurize and to depolymerize polymers formed in the first step. T. B. Tom and J. A. Bolt (2,693,442 to Standard Oil Co. of Ind.) disclose a method of extracting heavy mercaptans in a heater oil with a caustic methanol solution containing in addition to the methanol a substantial concentration of alkali metal salts of high molecular weight alkyl phenals. S. C. Haney and J. D. Moore (2,697,063 to Sinclair Refining Co.) treat a diesel fuel range distillate with Floridin clay at 600-700° F. and then extract the product with liquid sulfur dioxide to obtain a low sulfur fuel.

Removal of free sulfur from liquefied petroleum gas is the subject of Esso Research & Eng. Co.'s 2,693,443 (M. T. Waddell and J. H. Karchner). The hydrocarbons are contacted with a dilute aqueous solution of an alkali metal hydroxide which contains 0.84 percent of sodium methyl mercaptide.

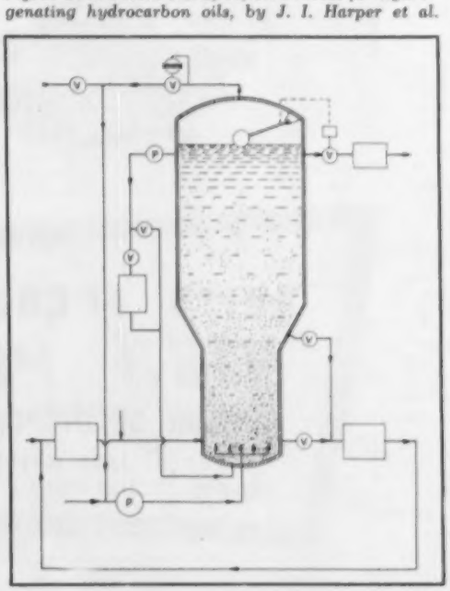
Alkylation and Isomerization

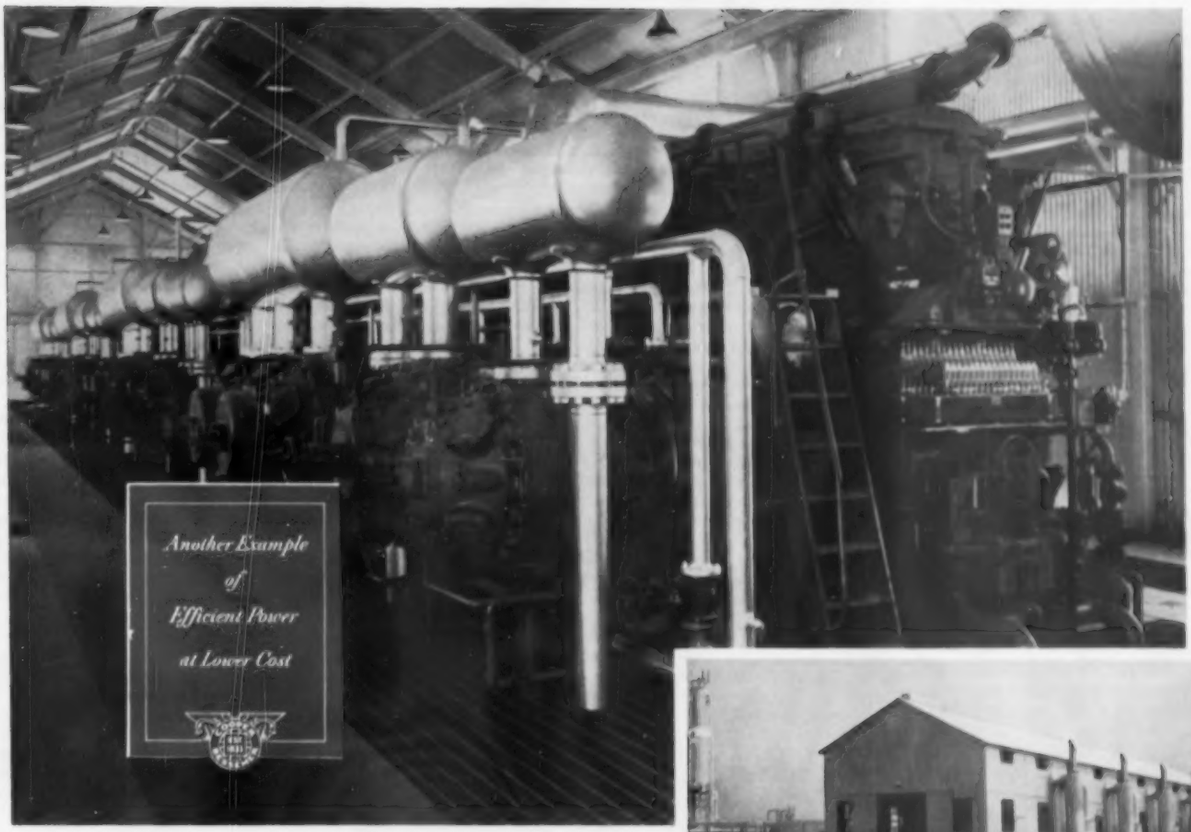
Relatively few new patents on alkylation have appeared and even fewer on isomerization reactions separate from those occurring in catalytic reforming. The revived interest in alkylation as a means of making high octane gasoline will probably be reflected in applications now pending and issuing in the future.

Production of 2,3-dimethylbutane from isobutane and ethylene in a two stage process is disclosed in 2,674,637 (R. S. Manne to Standard Oil Development Co.). A slightly hydrocarbon soluble Friedel-Crafts catalyst is employed in a first stage at 130-140° F. and a second stage at 95-105° F. at an overall space rate no greater than 3. In one of several Sun Oil Co. patents, K. M. Kennedy and A. Schneider (2,683,754-2,683,757) alkylate an olefin such as propene with the hydrocarbon part of a tert. alkyl fluoride, e.g. butyl fluoride in the presence of BF_3 and a substituted cyclopentane. Dimethylpentane isomers are formed by alkylation and dimethyl decalins by dimerization. The reaction is carried out in liquid homogenous phase. In 2,691,688 A. Schneider produces isopentane and 2,3-dimethylbutane by reacting isobutane with a paraffin having two tartiary hydrogen atoms in the presence of HF and isobutylene. S. J. Hetzel in Sun Oil Co. patent

(*Continued on page* 130)

Fig. 3: U. S. Patent No. 2,706,167. Process for hydrogenating hydrocarbon oils, by J. I. Harper et al.





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DIESELS • GAS ENGINES • GAS-DIESELS • ENGINE-DRIVEN AND MOTOR-DRIVEN COMPRESSORS

Patents

(*Continued from page 128*)

2,698,869 dealkylates monomethyl naphthalene to naphthalene by contacting it at elevated temperature with a microporous siliceous material and nickel in the presence of hydrogen or a hydrogen donor. Cobalt may be substituted for the nickel.

Alkylation of benzene with propene to yield cumene free of butyl benzene is described by G. D. Langlois (2,695,324 to California Research Corp.). The alkylation reaction product is intimately contacted with concentrated H_2SO_4, a hydrocarbon phase and an acid phase separated and the hydrocarbon phase washed with aqueous caustic and fractionated. L. B. Bos (2,698,867 to the Texas Co.) is concerned with the alkylation of phenol with a high molecular weight olefin polymer in the presence of anhydrous HF. Reaction conditions are 125-150° F., a phenol to polymer ratio of 3:1 or 4:1, an acid to olefin ratio of between 4:1 and 5:1 and a reaction time of 30-60 minutes.

Several patents deal with alkylation as a means of separating close boiling hydrocarbons. Sun Oil Co.'s 2,691,622 (R. M. Kennedy and A. Schneider) separates non-alkylatable aromatics from saturated non-aromatic hydrocarbons by bringing together in the presence of the hydrocarbon mixture a tert. mono-alkyl fluoride and boron trifluoride. The non-alkylatable aromatics are instantly converted to a separable sludge. American Cyanamid Co. patent 2,694,095 (E. C. Medcalf and G. N. Vriens) proposes separation of aromatic hydrocarbons from mineral oil fractions by alkylation of the aromatics with Friedel-Crafts type catalysts and separation of the products by fractionation.

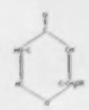
Phillips Petroleum Co. patent 2,695,325 (F. D. Stoops) describes a process for isomerizing n-paraffins with a catalyst comprising aluminum chloride and iron chloride on a carrier.

Refining

A very large number of patents issues each year which cannot readily be classified process-wise. Some of these patents are concerned with purification, others with separation of hydrocarbons, still others deal with disproportionation reactions or the removal of specific materials. This whole somewhat heterogenous group is considered here under the subject refining.

The removal of heavy metals and ashes from heavy hydrocarbons fractions is of major importance for catalytic cracking. G. A. Mills in Houdry Process Corp.'s 2,683,683 sulfides oils with hydrogen sulfide and ammoniacal hydrogen sulfide to precipitate insoluble heavy metal sulfides. These and excess sulfiding agent are removed prior to catalytic cracking. J. B. McKinley (2,689,825 to Gulf Research & Dev. Co.) contacts hydrocarbon oils with cracking catalyst fines at elevated temperature. The contaminant is adsorbed on the fines prior to treatment of the oil with active catalyst. F. W. B. Porter and R. P. Northcott (2,687,985 to British Petroleum Co.) remove sodium and vanadium from petroleum hydrocarbons by passing the hydrocarbons first over bauxite at about 780° F. and 1,000 psig pressure in the absence of hydrogen to remove sodium and then over bauxite at the same conditions in the presence of hydrogen to remove vanadium. Residual crude fractions are deashed according to R. S. Whiteley and A. Voorhies, Jr. (2,685,561 to Standard Oil Dev. Co.) by heat soaking at 550-770° F. for ½-8 hours to convert ash-forming constituents to insoluble compounds which are then filtered out. In another patent to the same company (2,682,496 R. W. Richardson and C. H. Hale) it is proposed to heat the oil to 600-700° F. and treat it with a phosphoric acid. Undesirable constituents are then removed by extraction with a aqueous solvent.

Negative catalysts by deactivating metal surfaces which normally catalyse gum formation is disclosed in 2,696,428 (D. R. Stevens to Gulf Res. & Dev. Co.) Traces of a compound of the following formula are added to the fuel:



Only a few patents can be considered here of the very large number dealing with the separation of hydrocarbons. G. J. P. Souillard (2,707,197 to Institut Français du Pétrole) separates cyclohexane from benzene by passing chlorine into the mixture at ambiant temperatures in the presence of light and absence of a catalyst. Cyclohexane is selectively chlorinated. Separation of cyclohexane from close boiling paraffins by means of azeotropic distillation is discussed in 2,679,472 (J. W. Touke to Phillips Petroleum Co.). Acetonitrile is used as a vapor entrainer. E. O. Box (2,693,496 to Phillips Petroleum Co.) describes the separation of ethylene and acetylene by selective polymerization of acetylene over a catalyst comprising chromia and calcium nickel phosphate. A method of separating various C_5 diolefins from each other by stepwise thermal polymerization is disclosed in 2,704,778 (D. S. Maisel to Esso Res. & Eng. Co.). Olefins and paraffins can be separated according to 2,685,607 (E. F. Pevere and G. B. Arnold) by contact with silica gel which has been impregnated with an aqueous silver nitrate solution, dried and calcined. Olefins are selectively adsorbed. Separation of branched chain from straight chain and cyclic hydrocarbons is accomplished by H. S. Bloch and E. M. Geiser (2,698,870 to Universal Oil Products Co.) by contact with an agent comprising a solid resinous condensation product of an aldehyde and a urea type compound at −10 to 50° C. Continuous cyclic adsorbtion-desorption processes for the separation of hydrocarbons are described in Standard Oil Dev. Co. patent 2,693,495 (S. H. Hastings, J. A. Anderson and A. T. Watson) and Phillips Petroleum Co. patent 2,696,510 (J. A. Weedman).

Extraction of hydrocarbons and hydrocarbon fractions has received wide attention during the past year. A number of Socony-Vacuum Oil Co. patents (2,681,302-303; 2,681,333-337; E. Gorin, H. C. Anderson and C. J. Delaney) treat the subject of urea and thiourea complex formation. A highly saturated solution of the complexing agent is passed down a tower. Hydrocarbons are introduced in the center section of the tower at a temperature lower

(*Continued on page 132*)

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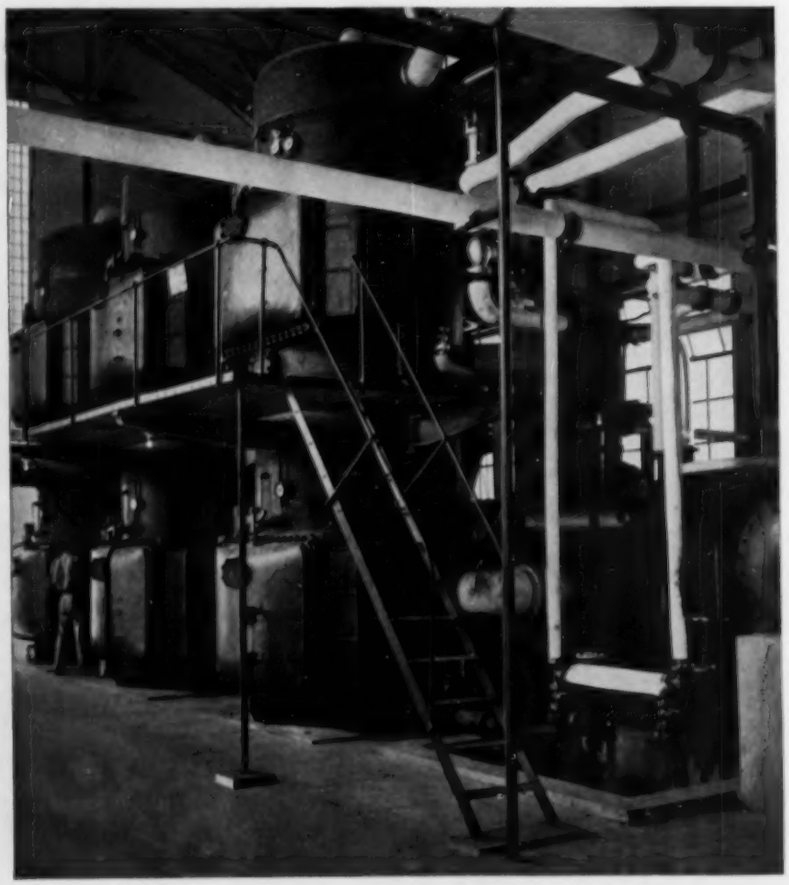

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Patents

(*Continued from page 130*)

than that of the solution and at which the solution becomes supersaturated and rigid globules are formed. The complex formed is decomposed in the lower part of the tower. A. S. Brengle (2,685,578 to California Research Corp.) proposes to separate *n*-paraffins by contact with solid urea wetted with 0.10 percent of a hydrocarbon liquid boiling below 250°F.

Extraction with sulfur dioxide is the subject of 2,689,819 (R. O. Shelton and G. H. Dale to Phillips Petroleum Co.). The solubility relationship between aromatic hydrocarbons and liquid sulfur dioxide is changed by use of a paraffinic or naphthenic stripping oil. J. E. Penick (2,689,822 to Socony-Vacuum Oil Co.) raises the octane number of a naphtha by extracting it with hydrogen fluoride containing 4-10 percent of an acid soluble oil. An improved process for continuously treating a fluid with a treating liquid which is immiscible therewith is disclosed in Shell Dev. Co.'s 2,679,470 (W. E. Kress). A. W. Francis in a group of Socony Mobil Oil Co. patents (2,698,276-278) describes the solvent extraction of lube oil stocks in which the solubility of the oil in solvents such as furfural, acetronitrile, etc. is increased by use of liquid carbon dioxide. W. C. Simpson (2,704,738 to Shell Dev. Co.) prepares a catalytic cracking feed stock from residual and asphaltic oils as extract phase by treatment with saturated C_3—C_5 hydrocarbons containing 1-10 percent of a water soluble inorganic salt or chromium, manganese, iron, cobalt or nickel.

Fluoride ion is removed from high boiling hydrocarbons by treatment with granular boric oxide at 200-350° F. and 10-500 mm. Hg pressure, according to J. P. O'Neil and J. M. Brooke (2,678,954 to Phillips Petroleum Co.). A method of removing water from hydrogen fluoride is disclosed in Standard Oil of Ind. Co's 2,697,065 (J. E. Wolf). O. M. Elliott dries kerosene and heavier hydrocarbons containing up to 1,000 ppm water by contact with a saturated aqueous solution of a hydroscopic lithium salt (2,674,562 to Sun Oil Co.).

A number of Standard Oil Co. of Indiana patents (2,683,758-762;2,700,689- D. A. McCauley and A. P. Lien) discuss isomerization and disproportionation reactions. Titanium tetrafluoride and hydrogen fluoride mixtures are used as catalysts to make, for instance, 1,3,5 ethyl xylene from xylene and ethyl benzene. Boron fluoride may be used in certain cases instead of titanium fluoride.

A gasoline antioxidant consisting of diamino durene or alkylated derivatives thereof is described in 2,681,271 (C. T. Y. Cowie to Imperial Chemical Industries Ltd.).

Catalysts

A large percentage of all petroleum chemical patents deal directly or indirectly with catalysts and contain methods of catalyst preparation. Patents reviewed in this section were selected from among the numerous ones which are disclosures of patentable new catalyst preparations rather than of processes employing catalysts.

A method of preparing a catalytic mass is discussed by E. J. Houdry in his patent 2,695,893. Stable, inert, porous supports are impregnated with particles of solid catalytic material by dispersing the catalyst in very finely divided form in a liquid vehicle containing in solution a gellable material. The support is immersed in the liquid dispersion so as to flow the fine particles into the pores. The gellable solution is precipitated in the pores.

Several patents describe alumina preparations. An alumina pebble of thermal and mechanical ruggedness and relatively stable against growth of corundum crystals is produced according to 2,680,692 (S. P. Robinson to Phillips Petroleum Co.) by incorporating 0.5-10 percent calcium or magnesium silicate into the alumina. Alumina spheres production is the subject of J. Hoekstra's 2,680,099 (to Universal Oil Products Co.). Alumina sol is commingled with hexamethylene tetramine and dropped into a water immiscible medium at elevated temperature. L. Heard (2,696,474 to Standard Oil Co. of Ind.) produces alumina hydrosols by contacting amalgamated aluminum at elevated temperature with a dilute aqueous solution of a weak organic acid containing also a neutral, water-miscible oxygenated organic solvent.

The preparation of hydrocarbon cracking catalysts continues to be an active field. L. B. Ryland (2,688,-003 to Shell Dev. Co.) prepares a microspheroidal silica-alumina catalyst by first forming microspheroidal sodium silicate particles of suitable composition and size range and then reacting these with a solution of an aluminum salt of an acid stronger than silicic acid. K. D. Ashley (2,701,793 to American Cyanamid Co.) precipitates and washes alumina gel in gelatinous hydrated silica to produce a silica-alumina catalyst. A sulfate free silica-alumina is prepared according to Davison Chemical Co.'s 2,684,340 (L. L. Barel and C. P. Wilson) by washing the mixed gel with an acidic solution, resulting in an effluent having a pH of 3-4 and then washing with an alkali metal free alkaline aqueous solution, so as to maintain a pH of 7-8 in the effluent. F. Nicholson and C. P. Wilson (2,685,569 to Davison Chemical Corp.) claim a silica-magnesia catalyst of improved carbon burning properties prepared by reacting a colloidal magnesium oxysalt with colloidal sodium silicate. Another silica-magnesia catalyst (2,703,789 J. B. McKinley and W. A. Pardee to Gulf Res. and Dev. Co.) comprises washed, dried, calcined and hydrothermally treated hydrogel formed from a slurry consisting of 25-80 percent of preformed finely divided silica-magnesia in aqueous sodium silicate solution with sufficient finely divided magnesia to give an overall MgO content of 22-33 per cent. Spent cracking catalyst of the silica-alumina type can be reactivated according to C. E. Starr and M. A. Segura (2,694,674 to Standard Oil Dev. Co.) by treating it with 0.1-5 percent hydrogen fluoride at 1,000-1,100° F. to incorporate 0.3-0.7 percent HF. The catalyst is then heat soaked in the absence of steam for 2-7 days at 1,050-1,150° F.

Phosphoric acid catalysts of improved characteristics are described in a number of Universal Oil Products Co. and Standard Oil Development Co. patents. M. J. Bielawsky and J. M. Mavity (2,694,-048 to U.O.P) claim a catalyst consisting of 60-80

(*Continued on page 134*)

"TUBEND"

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The Tubend range of welding fittings meet the requirements of practically every type of prefabricated pipe assembly and the facility, economy and efficiency of fabrication becomes even more marked when working in confined spaces and effecting difficult directional changes.

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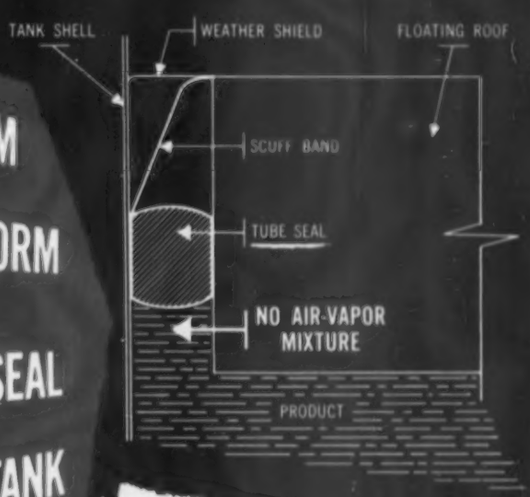

The Hammond Tubeseal Floating Roof is different from all other floating roofs because its design and construction does not provide space where air-vapor mixtures can form.

All floating roofs now in general use, except the *Hammond Tubeseal*, provide a space between the shell of the tank and the outer rim of the roof where air-vapor mixtures form

If a sour crude is stored in a conventional floating roof tank, excessive corrosion of the tank shell and rim plates will occur where air-vapor mixtures form. Unless the metal shoes and flexible fabric covers provide an absolutely gas-tight housing, some of the vapor will be lost. If the stored product is of intermediate volatility such as jet fuel (JP-4 grade) combustible vapors will exist in this space under all normal atmospheric temperature ranges. Any ignition as from lightning will cause violent combustion.

The Hammond Tubeseal eliminates this space and prevents the forming of any air-vapor mixture. Corrosion is stopped even for sour crudes. Jet fuels such as JP-4 grade may be stored with assured safety from rim fires. *Vapors which cannot form cannot ignite or be lost.* There is no room where vapor can form in a Hammond Iron Works Tubeseal Floating Roof.

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Patents

(*Continued from page* 132)

percent of an oxy acid of phosphorous and 40-20 percent of a solid carrier comprising 1-3 parts diatomaceous earth and 3-1 parts solid carbonaceous material. In 2,704,747 Bielawsky mixes over 50 percent of a phosphoric acid, a siliceous adsorbent and 0.5-10 percent of a cobalt compound. E. D. Reeves and K. K. Kearby (2,694,686 to S.O.D.) calcine a siliceous carrier with phosphoric acid and then impregnate the resultant silicon phosphate support with phosphoric acid. S. R. Bethea (2,681,374 to S.O.D.) maintain the phosphoric acid concentration of a polymerization catalyst at a desirable level while polymerizing wet C_3-C_5 olefins.

A desulfurization catalyst is described in Shell Dev. Co. patent 2,697,683 (W. F. Engel and H. Hoog). An alumina carrier which has been treated with a strong inorganic acid for at least 16 hours at 90° C. is impregnated with 6-8 percent molybdena and 12 percent cobalt and with 2.525 percent potassium based on molybdena. The catalyst is calcined in oxygen at 700-800° C. for 2-40 hours. H. L. Farrow (2,696,475 to Phillips Petroleum Co.) impregnates a porous carrier with an aqueous solution of a complex ammonium salt of nickel, cobalt or copper. Carbonates are precipitated and converted to metals.

A catalyst for the hydration of olefins and dehydration of alcohols is disclosed in 2,694,049 (P. W. Reynolds and L. R. Pitwell to Imperial Chemical Industries) which comprises intimate admixtures of titanium oxide and tungsten oxide.

New Hawthorne Bit Dealers

Herb J. Hawthorne, Inc., Houston, manufacturer of "Blue Demon" exploration drill bits, has announced the opening of two new authorized dealer stock points in the Rocky Mountain area. J. R. Anderson is in charge of the Anderson Seismograph Bit Service office in Casper, Wyoming, and C. M. Brown is in charge of the Teton Tool Co. office at Mills, Wyoming.

R. S. Durkee

Dresser Industries Appointment

Rodney S. Durkee has been elected a director and member of the executive committee of Dresser Industries, Inc., Dallas. Mr. Durkee is chairman of the Lane-Wells Co., which was recently acquired by Dresser, and an internationally prominent oil executive. He joined Lane-Wells as executive vice president in 1938 and has been the company's president since 1939.

Control Devices Catalog

A new 68-page catalog, GEC-1260A, on general purpose control devices, including a special section correlating by horsepower components for each type of motor control application, has been announced by the General Electric Company's General Purpose Control Dept., Schenectady 5, New York.

Buys Crescent Drilling Co.

Drilling and Exploration Co. of Los Angeles has acquired the equipment of the Crescent Drilling Co. of Monroe, La., consisting of ten rigs, and will continue to operate them in the Ark.-La.-Tex. and Gulf Coast areas, with headquarters at Monroe, managed by H. D. Pyke, formerly manager of the West Texas-Mexico division at Midland, Texas. Mr. Pyke is succeeded at Midland by his previous assistant Horace P. Goodrich. Other personnel changes are the addition of David A. Carnahan, formerly with Emsco, as chief engineer at Los Angeles; O. G. Barton transferred from California to Monroe, La., as drilling superintendent; and H. J. Stewart from Los Angeles to The Hague, Holland, as assistant to M. R. Garrison, manager of Drilvo, Drilexco's Dutch subsidiary.

FPC Natural Gas Rules

To eliminate the provoking search through antiquated volumes of the Federal Power Commission's Rules and Regulations, a compact, up-to-date compilation of the General Rules and Regulations Under the Natural Gas Act, excluding Subchapters F (Accounts) and G (Approved Forms), which were in force on January 1, 1955, is now available.

Information concerning this booklet may be obtained from Robert M. Harris, 3728 Gilbert Drive, Shreveport, La.

Pipe Line Corrosion Inhibitor

Universal Oil Products has announced that the use of Unicor, the company's new corrosion inhibitor, has been extended to product pipe lines as a result of a series of tests showing that Unicor protects pipe lines and storage equipment from ordinary rusting caused by moisture and air, as well as protecting steel and admiralty equipment from acid and ammoniacal attack in refinery units under anerobic conditions.

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Casting this water turbine runner in a single piece from aluminum-bronze was a considerable achievement.

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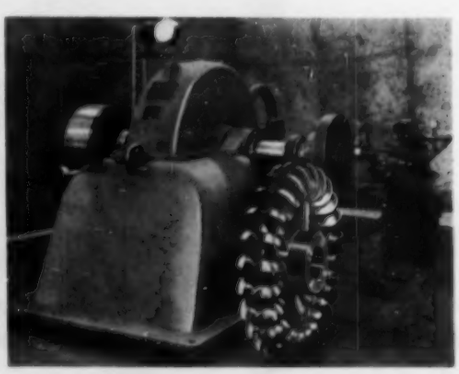

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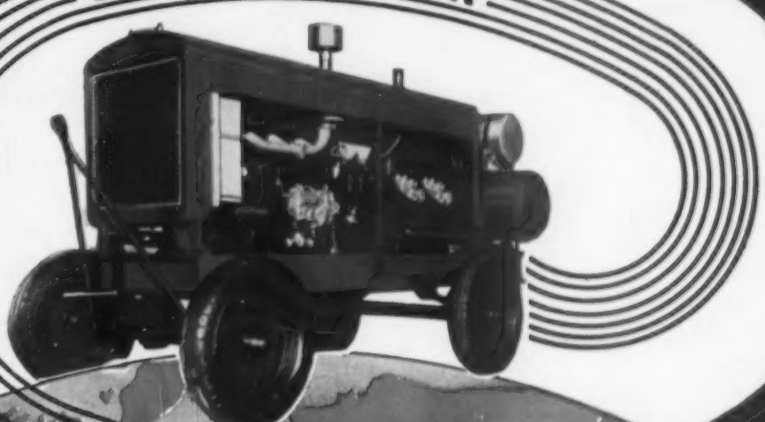

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AGENCY OFFICES IN PRINCIPAL CITIES THROUGHOUT THE WORLD

OIL REFINERIES OF THE WORLD

The tabulation below has been prepared to show the present capacities and status of oil refineries outside the United States where such information is available. No data is given on U.S.S.R. plants or refineries in nations dominated by the Russians. Capacities are barrels per day. Key to type of plant: S—Skimming; L—Lubricating; A—Asphalt; C—Cracking; Comp.—Complete. Under cracking capacity to indicate type: T—Thermal; C—Catalytic.

SUMMARY OF REFINERY CAPACITIES

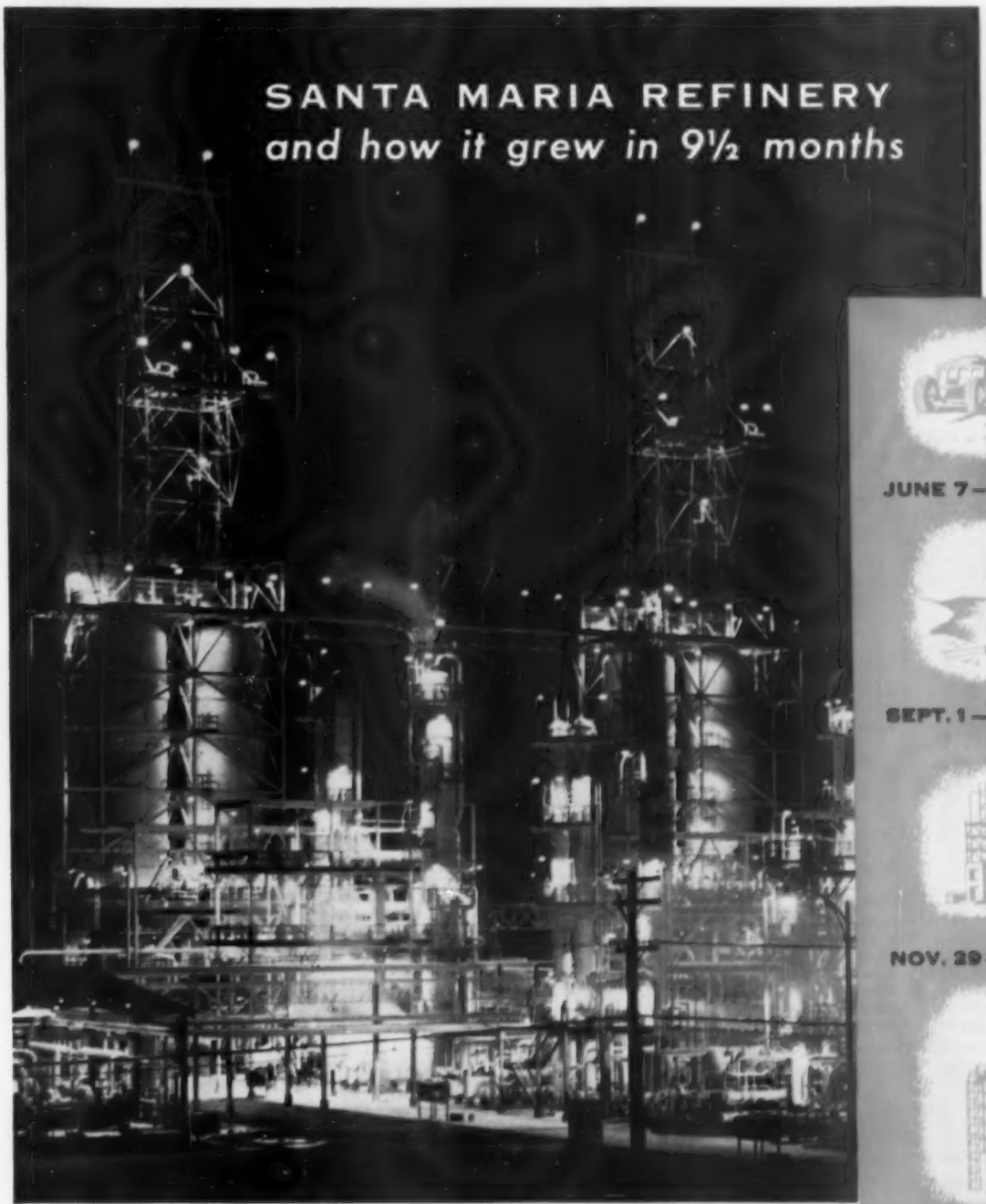
Operating or Operable Capacities, July 1, 1955

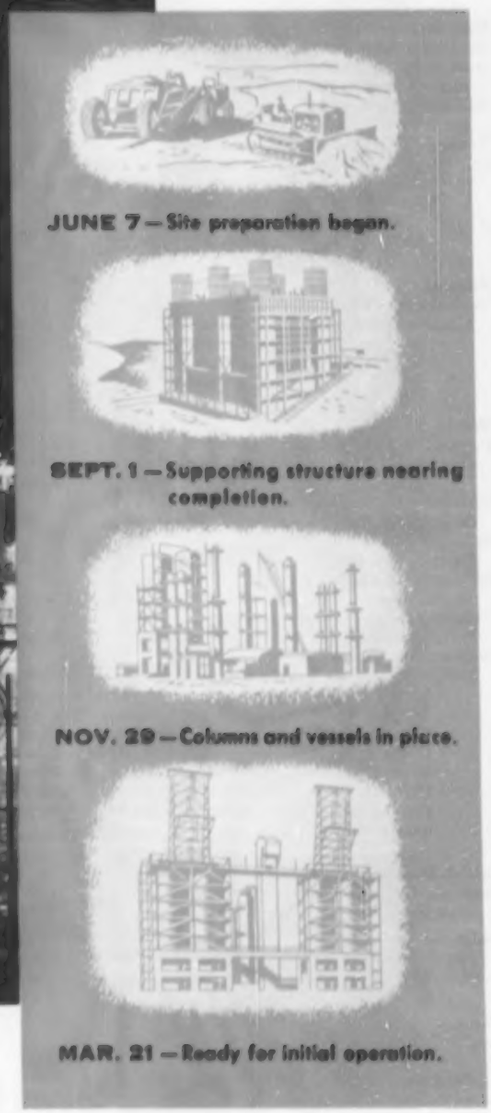
(*Estimated—**Unknown)

Country	No. Plants	Crude Capacity Barrels Daily	Cracking Capacity Barrels Daily
Aden	1	120,000	—
Albania*	1	3,000	—
Argentina	17	201,050	111,440T
Australia	6	107,700	49,500C
Austria*	7	42,862	—
Bahrain Island	1	186,500	37,700TC
Belgium	8	127,000	26,900TC
Bolivia	4	12,340	—
Brazil	7	91,950	45,000T
British Borneo	1	47,300	—
Bulgaria*	1	9,000	—
Burma	2	3,700	—
Canada	43	598,050	308,625TC
Chile	4	20,360	6,300T
China	1	9,000	—
Colombia	3	40,700	31,630TC
Cuba	6	11,100	2,000T
Czechoslovakia*	1	8,000	**
Denmark	3	995	—
Ecuador	2	6,050	—
Egypt	2	53,000	6,400T
Formosa	1	15,000	5,500T
France	15	543,128	61,450TC
Germany	33	279,730	71,600TC
Hawaiian Islands	1	3,000	—
Hungary*	3	35,000	**
India	3	75,300	7,100TC
Indonesia	5	224,300	44,500T
Iran	3	622,100	130,000TC
Iraq	5	53,530	16,000T
Israel	1	85,000	18,000T
Italy	35	445,200	33,050TC
Japan	16	214,500	21,930TC
Kuwait	1	30,000	—
Lebanon	2	17,500	—
Mexico	8	253,500	32,000T
Netherlands	2	235,000	59,000TC
Netherlands West Indies	2	640,000	483,000TC
Norway	1	2,000	—
Pakistan	1	5,000	1,500T
Peru	3	47,700	14,000T
Philippine Islands	1	13,000	5,400C
Poland*	1	5,000	**
Portugal	1	27,000	10,000C
Puerto Rico	1	10,000	—
Romania*	**	210,000	50,000**
Saudi Arabia	1	189,000	—
South Africa	2	17,600	7,700TC
Spain	3	60,250	3,500T
Sweden	4	40,900	1,000C
Switzerland	2	1,850	—
Trieste	3	23,500	—
Trinidad	3	120,000	27,500TC
Turkey	1	250	—
United Kingdom	17	614,600	133,300TC
USSR*	**	1,350,000	**
United States	326	8,420,000	2,535,000TC
Uruguay	1	28,000	1,800T
Venezuela	12	508,900	86,500T
Yugoslavia	3	19,800	1,100T
Totals	**644**	**17,185,787**	**4,468,825TC**
Western Hemisphere	442	11,009,700	3,684,795TC
Eastern Hemisphere	202	6,176,087	784,030TC

Name of Company	Plant Location	Crude Capacity	Type Plant	Cracking Capacity
Aden:				
Aden Petroleum Refinery, Inc.	Little Aden (1)	120,000	S	—
(1) 12,000 b/d Platforming capacity.				
Albania:				
Cerzic	Tirana-Eibasaan	3,000	SLA	—
Argentina:				
Cia. General Asfaltos	Wilde (B.A.)	370	L	—
Esso Sociedad Anonima Petrolera Argentina	Campana (B.A.)	25,000	Comp.	11,000T
	Bahia Blanca	5,500	SC	2,300T
	Manuel Eloridi	1,300	S	—
	Dadin	500	S	—
Condor	Avellaneda (B.A.)	1,000	S	—
Diadema Argentina S.A. de Petroleo	Buenos Aires (1)	21,000	SC	9,000T
La Isaura	Bahia Blanca (2)	1,880	SC	1,000T
Loterro y Papini	Avellaneda (B.A.)	300	SL	—
Ragor S.A.	Quilmes (B.A.)	150	SL	—
Y. P. F. (Enoe)	Dock-Sun Avellaneda (B.A.)	5,500	Comp.	3,000T
	Eva Peron	100,000	Comp.	59,000TC
	San Lorenzo (Santa Fe)	17,000	SC	13,000T
	Lujan de Cyuo (Mendoza)	11,900	SC	9,000T
	Chachapoyas (Salta)	2,500	SC	1,300T
	Plaza Huincul (Neuquen)	1,650	SC	540T
	Comodora Rividavia	5,500	SC	2,000T
(1) 3,000 b/d Thermal reforming capacity.				
(2) 2,000 b/d tube still plant under construction.				
Australia:				
Australian Oil Refinery Ltd.	Kurnell (Nr. Sydney) (1)	24,000	Comp.	15,000C
Australasian Pet. Ref. Ltd.	Kwinana (3)	62,000	SC	12,500C
Bitumen & Oil Refineries Ltd.	Sydney (3)	6,500	SA	—
Commonwealth Oil Refineries Ltd.	Laverton, Victoria	4,200	S	—
Shell Co. of Australia Ltd.	Clyde	10,000	SLA	—
Shell Ref. Pty (Aus.)	Geelong	36,000	SC	12,000C
Standard Vacuum Refinery Co. Ltd.	Altona (4)	25,000	Comp.	9,200C
(1) Construction of refinery scheduled to be completed late 1955.				
(2) 6,000 b/d Platforming capacity.				
(3) 1,400 b/d Platforming capacity. Platforming capacity to be increased to 2,300 b/d, 2,300 b/d Unifiner and a new 10,000 b/d crude unit under construction. Scheduled completion date: late 1955.				
(4) 1,600 b/d alkylation unit to be added in 1956.				
Austria:				
Vacuum Oil Co.	Kagran	4,200	SLA	—
A. G. de Shell-Floridsdorfer Mineraloelfabrik	Floridsodorf	3,400	SLA	—
Oesterreichische Mineraloelwerke (Soviet) (1)	Lobau	7,700	S	—
Benzin-Bensolverband (Soviet) (1)	Voesendorf	4,670	SLA	—
NOVA Mineraloel Raff. A.G. (Soviet) (1)	Schwechat	8,472	Comp.	—
Deutsche Gasolin (Soviet) (1)	Korneuburg	7,700	S	—
Donau Oel G.m.b.H. (Soviet) (1)	Moosbierbaum	6,720	SC	—
(1) Operated by the Soviet Mineral Oil Administration.				

UNION OIL COMPANY OF CALIFORNIA




JUNE 7—Site preparation began.
SEPT. 1—Supporting structure nearing completion.
NOV. 29—Columns and vessels in place.
MAR. 21—Ready for initial operation.

The fast schedule at Santa Maria reflects close co-operation between client and engineer-constructor. It was another turn-key project under Bechtel responsibility—from process design to construction.

BECHTEL BUILDERS FOR INDUSTRY

BECHTEL CORPORATION *Los Angeles* · SAN FRANCISCO · *New York*

CANADIAN BECHTEL LIMITED · *Toronto*

Name of Company	Plant Location	Crude Capacity	Type Plant	Cracking Capacity
Bahrain Island:				
Bahrain Petroleum Co.	Bahrain, Persian Gulf [1] [2]	186,500	Comp.	37,700TC [3]

[1] 23,000 bd Vacuum unit scheduled for 1955 completion, 18,000 b/d FCCU, 23,000 bd Vacuum unit and 1,500 poly plant scheduled for 1957 completion.
[2] 19,500 b/d thermal reforming capacity.
[3] 21,000 b/d catalytic cracking capacity and 15,700 thermal cracking capacity.

Belgium:				
"Albatros" S.A. Belge pour le Raffinage de Petrole	Antwerp, Kiel [1]	11,000	SC	3,600C
Belgian Shell Co. S.A.	Ghent	3,000	SLA	—
Compagnie Industrielle "Atlas" S.A. (Esso)	Hoboken-Antwerp	2,500	S	—
Esso Standard Ref. S.A.	Antwerp [2]	28,000	SC	11,000C
Raffinerie Belge de Petroles	Antwerp [3]	15,000	SCA	2,300T
Raffineries et Distilleries Anversoise S.A. "Radain"	Antwerp [4]	4,000	S	—
Soc. Industrielle Belge des Pet.	Antwerp [5]	60,000	SC	10,000C
Tankage et Transport S.A.	Antwerp	3,500	S	—

[1] Crude capacity to be increased to 15,000 b/d.
[2] 3,600 b/d thermal reforming capacity, 2,500 b/d cat reformer planned.
[3] 2,500 b/d thermal reforming capacity.
[4] 750 b/sd cat reforming capacity.
[5] 6,000 b/d thermal reforming capacity.

Bolivia:				
Yacimientas Petroliferous Fiscales Bolivianos	Cechamba	5,850	S	—
	Seucre	4,630	S	—
	Camiri	1,450	S	—
	Sanandita	410	S	—
Brazil:				
Petroleo Brasileiro S.A. (Petrobras)	Mataripe [1]	5,000	SC	3,000T
	Cubatao [2]	50,000	SC	40,000T
Distillaria Rio Grandense de Petroleo S.A.	Rio Grande do Sul	300	S	—
Industrias Matarazzo de Energia S.A.	Sao Paulo	500	S	—
Ipiranga S.A. Cia. Brasileira de Petroleo	Rio Grande do Sul	6,000	SCA	2,000T
Refinaria e Exploracao de Petroleo Uniao	Sao Paulo	20,000	S	—
Refinaria de Exploracao de Manguinhos	Rio de Janeiro	10,000	S	—

[1] 1,500 b/d Thermal reforming cap. Crude capacity to be increased to 15,000 b/d and refinery is to produce 3,000 b/d lubricating oils, 60 tons wax, F.C.C.U., 6,300 b/d cat poly. Scheduled completion: End 1957.
[2] Crude capacity to be increased to 60,000 b/d in 1955 and to 75,000 b/d later. 3,500 b/d asphalt plant under construction to be complete Nov. 1955. Also under construction an ethylene recovery unit. Companhia de Petoleo de Amazonia is building a 5,000 b/d refinery at Manaus. Scheduled completion date late 1955.

British Borneo:				
Sarawak Oilfields Ltd.	Lutong, Sarawak	47,300	S	—

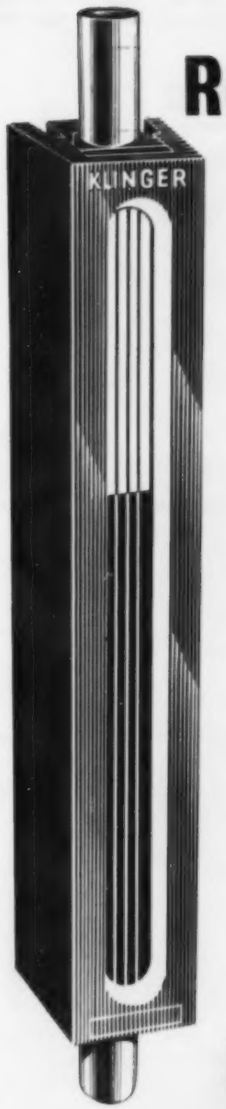
Bulgaria:

In the absence of official information, recent estimates indicate 1 refinery in operation in Bulgaria with a daily capacity of 9,000 barrels.

Canada:				
Anglo-Canadian Oil Ltd.	Brandon, Manitoba [1]	3,000	SC	1,375T
Anglo-American Exp. Ltd.	Hartell, Alta [2]	2,500	Comp.	1,500T
Bonneyville Oil Refineries	Bonneyville, Alta.	1,100	S	—
British American Oil Co. Ltd.	Calgary, Alta. [3]	7,200	SC	2,500T
	Edmonton, Alta. [4]	7,000	SC	3,400TC
	Moose Jaw, Sask. [5]	15,000	SCA	6,000TC
	Clarkson, Ont. [6]	21,500	Comp.	16,100TC
	Montreal, Que. [7]	45,000	SCA	21,000TC
Canadian Oil Refineries Ltd.	Sarnia, Ont. [8]	22,000	SC	11,800TC
Canadian Petrofina	Montreal, Que. [9]	20,000	Comp.	13,800TC
Consumers' Co-operative Ref.	Regina, Sask.	12,000	SCA	3,100T
Excelsior Refineries Ltd.	Lloydminster, Alta.	3,000	SA	—
Hi-Way Refineries Ltd.	Moose Jaw, Sask. [10]	350	S	—
	Rosetown, Sask. [10]	350	S	—
Husky Oil & Ref. Ltd.	Lloydminster, Alta. [11]	8,500	SA	—
	Ft. Williams, Ont. [12]	4,000	SA	—
	Moose Jaw, Sask. [13]	3,000	SA	—
Imperial Oil Limited	Montreal, Que. [14]	46,000	SCA	27,100TC
	Halifax, N. S. [15]	18,000	SCA	10,000C
	Sarnia, Ont.	78,000	Comp.	23,300TC
	Winnipeg, Man.	12,000	SCA	4,100C
	Regina, Sask. [16]	22,500	SCA	15,600TC
	Edmonton, Alta. [17]	25,000	SC	17,200TC
	Calgary, Alta.	9,200	SCA	4,600T
	Vancouver, B. C. [18]	22,500	SCA	7,500C
	Norman Wells, NWT	1,250	S	—
McColl-Frontenac Oil Co. Ltd.	Montreal East, Que. [19]	45,000	SC	32,100TC
	Edmonton, Alta. [20]	11,000	SC	4,800TC
New Brunswick Oilfields Ltd.	Weldon, N. B.	300	S	—
Northern Petroleum Corp. Ltd.	Kamsack, Sask.	800	S	—
North Star Oil Ltd.	St. Boniface, Man. [21]	12,000	SC	850T
Prince Albert Refineries Ltd.	Prince Albert, Sask.	1,000	SLA	—
Petroleum Fuels Ltd.	Moose Jaw, Sask.	1,000	S	—
Royalite Products Ltd.	Kamloops, B. C.	5,000	Comp.	1,425C
	Coleville, Sask. [22]	5,000	SA	—
Radio Oil Refineries Ltd.	East Kildonan, Man.	500	S	—
Royalite-Hiway Ltd.	Saskatoon	6,500	SCA	2,600C
Shell Oil Co. of Canada Ltd.	Shellburn, B. C. [23]	18,000	Comp.	10,100TC
	Montreal East. [24]	44,000	Comp.	25,500TC
Standard Oil Co. of B. C. Ltd.	N. Burnaby, B. C. [25]	11,500	Comp.	7,500C
Sun Oil Co.	Sarnia, Ont. [26]	15,000	SC	11,000C
Supreme Refineries, Inc.	Ogden	500	S	—
Trinidad Leaseholds (Canada) Ltd.	Port Credit, Ont. [27]	8,000	SC	6,600TC
Wainwright Refineries Ltd.	Wainwright, Alta.	3,000	S	—

[1] 1,000 b/d Platforming capacity.
[2] 1,500 b/d cat. reformer under construction.
[3] 2,000 b/d cat. reforming capacity.
[4] 1,400 b/d thermal cracking capacity and 2,000 b/d catalytic cracking capacity.
[5] 1,500 b/d thermal cracking capacity and 4,500 b/d catalytic cracking capacity.
[6] 4,500 b/d thermal cracking capacity and 11,600 b/d catalytic cracking capacity.
[7] 3,500 b/d thermal cracking capacity and 17,500 b/d catalytic cracking capacity. Under construction: 13,000 b/d cat. reformer. Scheduled completion: Late 1955.
[8] 3,500 thermal cracking capacity, 8,300 b/d catalytic cracking capacity, 4,000 b/d catalytic reforming capacity. Under construction: crude capacity to be increased to 25,000 b/d. Scheduled completion: 1956.
[9] Plant under construction. Will be complete Mid 1955.
[10] Closed down since 1949.
[11] 500 b/d catalytic reforming capacity.
[12] Formerly owned by Riverlakes Oils Limited. 1,000 b/d catalytic reforming capacity.
[13] Formerly owned by Moose Jaw Refineries Ltd. 600 b/d catalytic reforming capacity.
[14] 10,600 b/d thermal cracking capacity and 16,500 catalytic cracking capacity. Under construction: 4,400 b/d atmospheric and vacuum still, 11,100 b/d vacuum pipe still and 19,500 b/d cat cracker.
[15] Under construction: 41,625 b/d atmospheric and vacuum unit, 15,200 b/d fluid cat cracker, 3,150 b/d naphtha reformer, 10,624 b/d visbreaker, 4,000 b/d thermal cracking and 19,300 b/d catalytic cracking. Scheduled completion: Summer 1956.
[16] 7,500 b/d thermal cracking capacity, 8,100 b/d catalytic cracking capacity and 3,100 thermal reforming capacity.
[17] Under construction: Equipment for lube oil manufacture including phenol, ketone, dewaxing, hydrofinishing plants, package plant and warehouse.
[18] Under construction: 2,340 b/d cat poly unit, treating facilities and 2,400 b/d naptha facilities. Scheduled completion: October 1955.
[19] 14,100 b/d thermal cracking capacity, 18,000 b/d catalytic cracking capacity and 4,500 b/d thermal reforming capacity.
[20] 3,100 b/d thermal cracking capacity and 1,700 b/d catalytic cracking capacity.
[21] 1,100 b/d thermal reforming capacity.
[22] Formerly owned by Refinery Operators Ltd.
[23] 3,500 b/d thermal cracking capacity, 6,600 b/d catalytic cracking capacity and 1,700 b/d thermal reforming capacity. Under construction: 3,300 b/d Platformer planned for construction. Scheduled completion: Late 1955.
[24] 9,000 b/d thermal cracking capacity, 16,500 b/d catalytic cracking capacity. Under construction: 3,000 b/d cat cracker expansion. Scheduled completion: Sept. 1955. 6,600 b/d Platformer, 11,000 b/d topping plant and 7,500 b/d hydrodesulfurizer. Scheduled Completion: July 1956.
[25] Under construction: 18,000 b/d refinery expansion. Scheduled Completion: Late 1955.
[26] 3,000 b/d thermal reforming capacity.
[27] 4,100 b/d thermal cracking capacity, 2,500 b/d catalytic cracking capacity and 2,300 thermal reforming capacity. Under construction: To increase capacity to 14,000 b/d. Scheduled completion: August 1955.

Reliability and Readability



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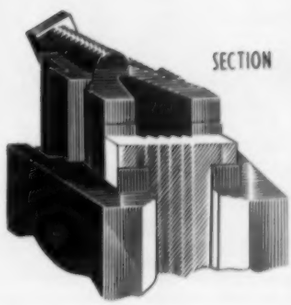

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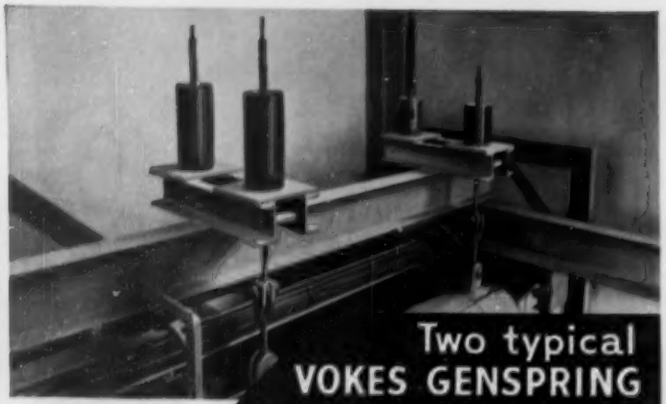
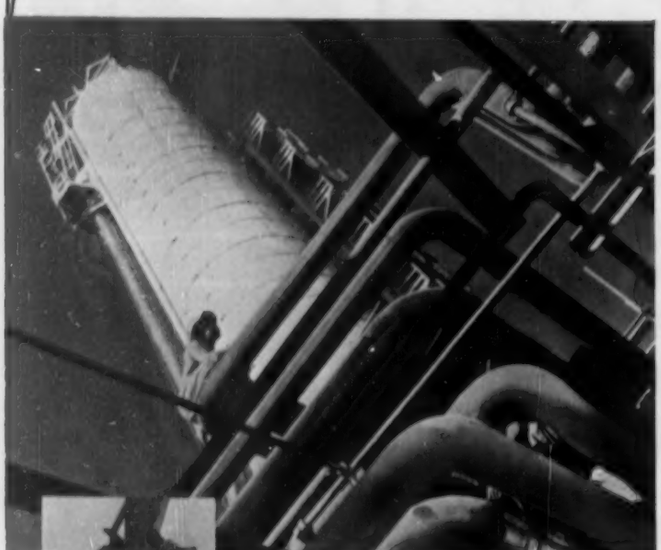


Photograph by courtesy of The Associated Ethyl Company Limited.

Two typical VOKES GENSPRING hanger installations in the oil industry

IN ADEN, The British Petroleum Company's new refinery came on stream in July 1954. Many sections of this complicated process plant piping demand the finest and most accurate suspension methods, and this requirement has been met by the installation of Vokes Genspring Variable Support Hangers. The Associated Ethyl Company Limited have also made use of these Vokes Genspring Hangers at their Ellesmere Port Works in Cheshire.



Photograph by courtesy of The British Petroleum Company Limited.

VOKES GENSPRING Variable Support Hangers are specifically designed for the control of vibration and limited thermal movement of piping, but where piping systems need to be 'floated' to offset the efforts of extensive movement, Vokes Genspring Constant Support Hangers should be used. The full range is detailed in the Vokes Genspring catalogues available on request.

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VG/4

Name of Company	Plant Location	Crude Capacity	Type Plant	Cracking Capacity
Burma:				
Burmah Oil Co.	Chauk (1)	3,000	Comp.	—
Nathsingh Oil Co. Ltd.	Yenangyaung	700	S	—
(1) 2,500 b/d distillation unit under construction.				
Chile:				
Johannsen, G. H.	Coquimbo, Chile	125	S	—
Maritano, Miguel	Talcahuano	60	S	—
Soc. Establecimientes Quimicos	Via del Mar	175	S	—
Empresa Nacional del Petroleo	Concon (1)	20,000	SC	6,300T
(1) 4,160 b/d reforming capacity.				
China:				
Chinese Government	Kensu	9,000	S	—
Colombia:				
Colombian Petroleum Co.	Tibu	2,200	S	—
Empresa Colombiana	Barrancabermeja (1)	37,500	Comp.	31,630TC
International Petroleum (Colombia) Ltd.	Cartagena (2)	26,500	SC	13,130C
The Texas Petroleum Co.	Guamo (3)	1,000	S	—
(1) Plant owned by Empresa Colombiana de Petroles. Operated under contract by International Petroleum.				
(2) Refinery under construction. To be complete last quarter 1957.				
(3) Increasing charging capacity to 1,200 b/d.				
Cuba:				
Cia. Exploradora de Petroleo	Jarahueca	400	S	—
Cia. Petrolera Jarahueca	Jarahueca	600		S—
Cuban Oil Ref. Co.	Cabaiguan	1,000	SC	500T
Destiladora Jarahueca	Santa Clara	200	S	—
Esso Standard Oil Co.	Belot	8,600	SCA	1,500T
Union Gas Co.	Bacaranao	300	S	—
Note: The Texas Co. is planning to build a 20,000 b/d refinery at Santiago.				
Czechosolovakia:				
In the absence of official information, recent estimates indicate a total of 1 refinery in Czechoslovakia with a daily crude capacity of 8,000 barrels.				
Denmark:				
A/S Kalundborg Oileraffinaderi	Kalundborg	850	SA	—
Dansk Mineraloliefabrik	Copenhagen	65	SL	—
L. C. Glad & Co.	Copenhagen	70	SL	—
Ecuador:				
Anglo Ecuadorian Oilfields Ltd.	La Libertad	5,600	SLA	—
Manabi Exploration Co.	Cautivo	450	S	—
Egypt:				
Anglo-Egyptian Oil Fields Ltd.	Suez	44,000	SCA	6,400T
Raffinerie de Petrole du Government	Suez (1)	9,000	SA	—
(1) Planning to increase capacity to 26,000 b/d.				
Note: Refinerie de Petrole du Government planning to build refinery of 20,000 b/d capacity at Cairo.				
Finland:				
Neste Corp. to build an 18,000 b/d refinery at Turku. Contract was signed recently.				
Formosa:				
Chinese Petroleum Corp.	Kaoshiung, Taiwan (1)	15,000	SCL	5,500T
(1) 3,100 b/d cat reforming capacity under construction. 10,000 b/d thermofor cat cracker. Scheduled completion: late 1955 or early 1956.				
France:				
Compagnie Francaise de Raffinage	La Mede (1)	68,000	SAC	14,000TC
	Gonfreville (2)	75,000	Comp.	9,000T
Compagnie de Raffinage Shell-Berre	Petit-Couronne (3)	50,000	Comp.	5,500T
	Pauillac	12,000	SA	—
	Berre (4)	75,000	Comp.	10,000TC
Pechelbronn SAEM	Merkwiller	1,600	Comp.	200T
Raffineries Francaises de Petrole de L'Atlantique	Donges (5)	32,000	SC	10,600C
Raff. de Petrole de la Gironde	Bec d'Ames (6)	20,000	S	—
Ste. Cherifienne des Petroles	Petitjean (Morocco)	4,000	SC	2,650C
Ste. Francaise des Petroles B.P.	L'Avera (7)	50,000	S	—
	Dunkerque (8)	45,000	Comp.	—
Socony-Vacuum Francaise	N. Dame de Gravenchon (9)	17,250	SL	—
	Frontignan (10)	22,000	SC	11,000C

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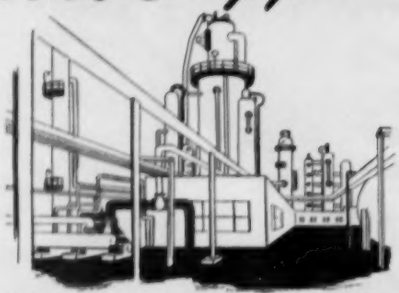

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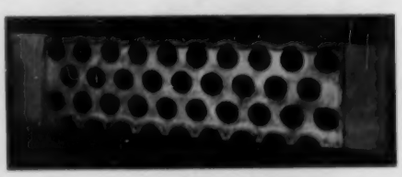

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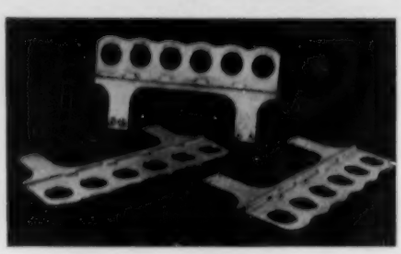

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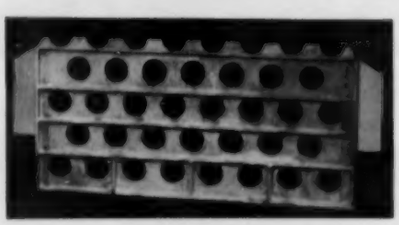

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Name of Company	Plant Location	Crude Capacity	Type Plant	Cracking Capacity
Esso Standard Societe Anonyme Francaise	Port Jerome (11)	75,000	Comp.	10,000C
	La Mailleraye (12)	770	S	—

(1) 11,000 b/d Thermal Reforming Capacity. Under construction: Crude distillation unit. Scheduled Completion: September 1955.
(2) 13,000 b/d Thermal Reforming Capacity. Under construction: cat cracker. Scheduled Completion: May 1956.
(3) 3,500 b/d Thermal Reforming Capacity. Under construction: 8,000 b/d cat cracker. Scheduled Completion: Mid 1956.
(4) 9,000 b/d Thermal Reforming Capacity.
(5) 4,400 b/d Thermal Reforming Capacity.
(6) 3,699 b/d Thermal Reforming Capacity. Under construction: 4,600 b/d cat cracker. Scheduled Completion 1957. 6,300 b/d vacuum unit, 540 b/d polymerization plant. Scheduled Completion: 1956.
(7) 5,000 b/d Thermal Reforming Capacity, 6,000 b/d Platforming capacity.
(8) 6,000 b/d Thermal Reforming Capacity.
(9) 2,600 b/d Thermal Reforming Capacity. Under construction: 4,100 b/d Sovaformer.
(10) 2,600 b/d Thermal Reforming capacity.
(11) 11,500 b/d Thermal Reforming capacity. Under construction: Polymerization unit.
(12) Medicinal and technical white oil greases and special products.

Germany:

Badische Anilin & Sodafabrik	Ludwigshafen-on-Rhine	800	S	—
BP Benzin-und Petroleum GmbH (British Petroleum Co. Ltd.)	Hamburg-Finkenwerder (1)	30,000	SCA	6,000T
Coelner Benzin-Raffinere	Cologne (2)	320	(3)	—
Deutsche Erdoel-A.G.	Heide	12,600	Comp.	7,000C
	Weitze	1,000	SLA	—
	Hamburg-Grasbrook	1,400	SL	—
Deutsche Gasolin A.G.	Dollbergen-Lehrte	2,500	Comp.	—
Deutsche Shell A.G.	Hamburg-Harburg	10,000	SLA	—
	Monheim on Rhine	4,000	SLA	—
	Hamburg-Grasbrook (2)	1,700	L	—
	Duesseldorf-Reisholz (2)	900	(3)	—
	Hamburg-Wilhelmsburg	850	(3)	—
Deutsche Vaccum Oel A.G.	Bremen-Oslebshausen	15,300	Comp.	7,700C
	Wedel on Elbe	1,000	L	—
Esso A.G.	Hamburg-Harburg (4)	39,000	Comp.	10,000C
Gelsenberg Benzine A.G.	Gelsenkirchen (5)	49,000	SH	10,000C
Gewerkschaft Deurag-Nerag	Misburg nr. Hannover (6)			
Gew. Erdoel-Raff. Emsland	Lingen-on-Ems	11,800	Comp.	4,500T
Gew. Grieff Bergbau	Dollbergen	500	SL	—
Johann Haltermann	Hamburg-Wilhelmsburg (2)	2,000	(3)	—
Kraftsoff-Handelsgesellschaft GmbH.	Essen (7)	1,700	S	—
Mineraloel-und Asphaltwerke A.G. (MAWAG)	Ostermoor on Kiel Canal	2,100	SA	—
Mineraloelwerke Albert Sengewald	Dedenhausen (Hannover) (7)	900	SL	—
Mineraloelwerke Albrecht & Co.	Hamburg-Grasbrook (2)	250	SL	—
Mineraloelwerke Peine (Schindler)	Peine (Hannover)	390	SL	—
Oelwerke Julius Schindler GmbH	Hamburg-Neuhof	5,600	SLA	—
Ruhrbau GmbH	Muelheim on Ruhr (7)	6,500	S	—
Ruhrchemie, A.G.	Oberhause-Holten (8)	11,000	Comp.	6,000TC
Ruhroel GmbH	Bottrop (9)	2,700	S	—
Schloven-Chemie A.G.	Gelsenkirchen-Buer (10) (11)	21,500	SCH	5,100C
Union Rheinische Braunkohlen Kraftstoff A.G.	Wesseling nr. cologne (12)	28,000	SCH	11,800T
Wintershall A.G.	Salzbergen (Emsland)	2,300	L	—
Zeller & Gmelin	Eislingen (Wuerttemberg) (7)	170	SL	—

(1) 3,200 b/d thermal reforming capacity and 6,000 b/d Platforming capacity.
(2) Half finished charging capacity.
(3) Type of gasoline rerunning.

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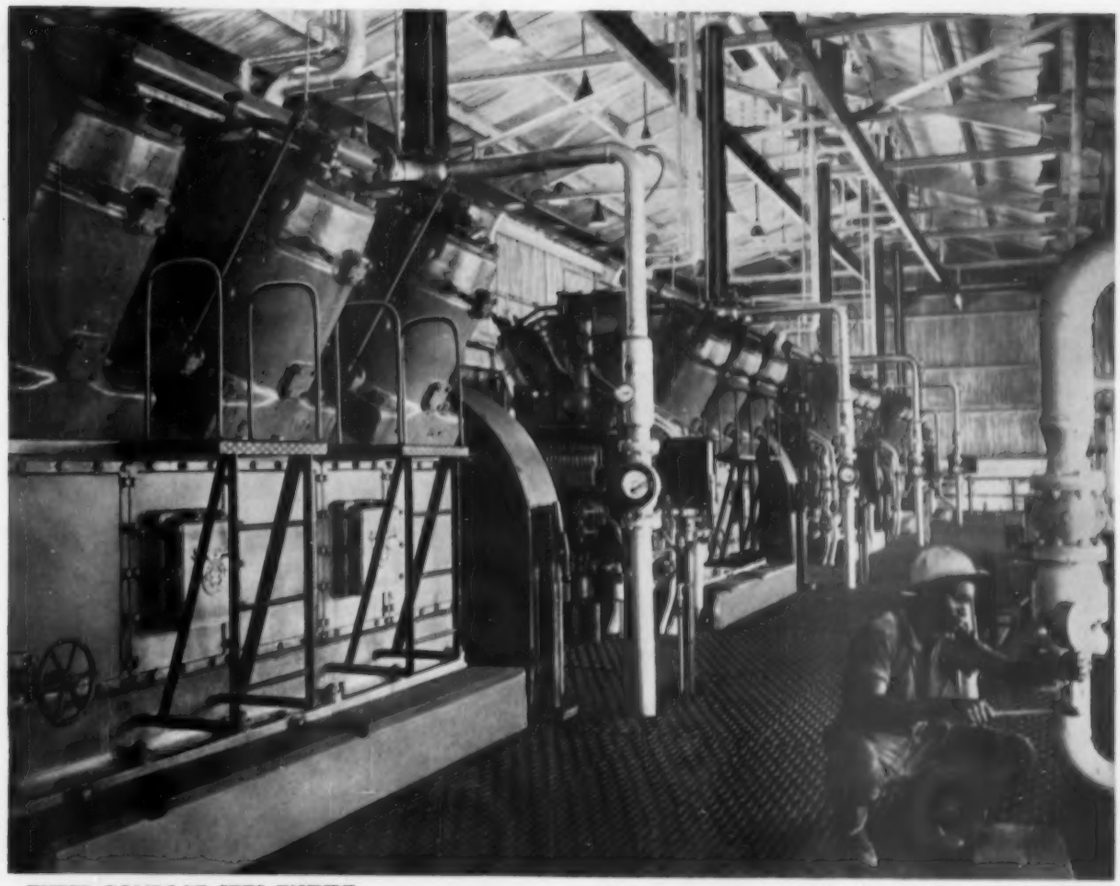
Name of Company	Plant Location	Crude Capacity	Type Plant	Cracking Capacity
(Germany, continued)				
	(4) 3,800 b/d thermal reforming capacity. Under construction: crude capacity to be increased to 43,000 b/d and 7,000 b/d cat. reforming. Scheduled completion: 1956.			
	(5) 7,100 b/d cat. reforming capacity.			
	(6) 2,100 b/d thermal reforming capacity. Under construction: 2,600 b/d Platformer.			
	(7) Temporarily shut down.			
	(8) 2,000 b/d thermal reforming capacity, 2,000 b/d thermal cracking capacity, 4,000 b/d catalytic cracking capacity.			
	(9) 2,500 b/d thermal reforming capacity. Reconstruction of the hydrogenation unit and construction of a cat cracker, 5,500 b/d crude oil charging capacity each.			
	(10) 2,100 b/d thermal reforming capacity.			
	(11) 6,500 b/d intake capacity for Hydrogenation.			
	(12) 7,100 b/d intake capacity for Hydrogenation.			
Greece:				
	Greek Government to build a 30,000 b/d refinery. Plant will include thermal cracker and cat reformer. Completion planned for 1957.			
Hawaiian Islands:				
Pacific Refiners Ltd.	Honolulu, Oahu (1)	3,000	SA	—
	(1) Operates on reduced crude and butane.			
	Standard Oil Co. of Calif. to build a 20,000-30,000 b/d refinery at Honolulu.			
Hungary:				
	In the absence of official information, recent estimates indicate 3 refineries in operation in Hungary with a daily capacity of 35,000 barrels.			
India:				
Assam Oil Co.	Digboi	7,500	Comp.	2,000T
Burmah-Shell Refineries	Bombay	40,000	S	—
Caltex Oil Co.	Vishaktnam (1)	13,500		—
Standard Vacuum Oil Co.	Bombay (Trombay) (2)	27,800	Comp.	5,100C
	(1) Refinery under construction. To be complete in 1957.			
	(2) 4,200 b/d thermal reforming capacity.			
Indonesia:				
N.V. de Bataafsche Petroleum Mij. (Shell)	Balik Papan, N.E. Borneo	55,000	SW	—
	P. Brandon, Sumatra (1)			
	Paladju, Sumatra (2)	90,000	SC	10,000T
	Tjepu, Java	4,600	S	—
	Wonokroma, Java	3,200	SA	—
N.V. Standard Vacuum Petroleum Mij.	Sungi, Gerong	71,500	SCW	34,500T
	(1) Impossible to resume operations. Former capacity 23,000 b/d.			
	(2) 15,000 b/d thermal reforming capacity.			
Iran:				
National Iran Oil Co. (1)	Abadan (3)	550,000	Comp.	130,000TC
	Kerminshah	2,100	S	—
	MIS (3)	70,000	T	—
	(1) Operated by Iranian Oil Refining Co.			
	(2) 95,000 b/d thermal cracking capacity and 35,000 cat cracking capacity.			
	(3) Crude topping plant for Abadan refinery; makes no finished products, ships tops or bottoms to Abadan by pipe line as required for finishing.			
Iraq:				
Iraq Petroleum Co.	Bab Gurgur	13,500	S	—
Kanaquin Oil Co. Ltd.	Alwand	11,400	S	—
	Basrah	3,430	S	—
Government Oil Refineries	Baghdad	24,000	Comp.	16,000T
2 " " "	Qaiyarah	1,200	A	—
Israel:				
Consolidated Refineries Ltd.	Haifa, Israel (1)	85,000	SGA	18,000T
	(1) 20,000 b/d thermal reforming capacity.			
Italy:				
Anonima Petroli Italian (API)	Falconara (1)	26,000	SA	8,000T
Asfalti Bitumo-Catramie Derivati (ABCD)	Ragusa, Sicily	100	A	—
Aurora	Marghera, Venice	400	S	—
Bianchi Petroli	Cologno Monzese (2)	1,250	S	—
CONDOR	Rho	45,000	SC	15,000C
Delle Piane	Genoa	1,000	S	—
Distilleria Italiana Cantrami Affini (DICA)	Carrara	3,000	S	—
Galletti	Florence	3,700	S	—
Garrone	Genoa (3)	21,000	S	—
Industria raffinazione Oli Minerali (IROM)	Marghera, Venice (4)	30,000	Comp.	800T
I.C.I.P.	Mantova	10,000	SC	4,000T
	Mantura	12,000	S	—
Idrocarburi Nazionali (SIN)	Pietramala, Florence	1,000	S	—
I.P.L.O.M.	Genoa	1,000	S	—

GMV's FOR OIL REFINERIES



THESE COMPACT SETS ENSURE ECONOMY IN HOUSING AND INSTALLATION COSTS

Gas compressors at Trinidad for catalytic cracking plant of Trinidad Leaseholds, Ltd. The installation consists of five GMV6 gas compressors, one GMX4 gas compressor and one GMX4 auxiliary high pressure air compressor.

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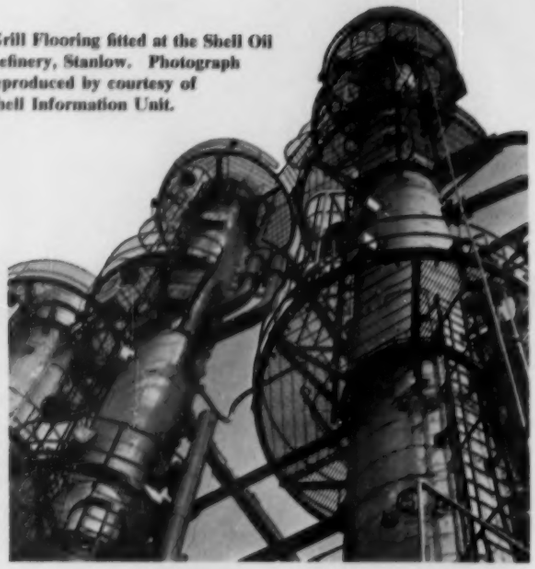
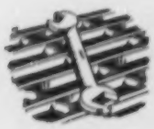


Grill Flooring fitted at the Shell Oil Refinery, Stanlow. Photograph reproduced by courtesy of Shell Information Unit.

GRILL FLOORS

NON-SLIP



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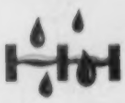

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Name of Company	Plant Location	Crude Capacity	Type Plant	Cracking Capacity
(Italy, continued)				
I.L.S.E.A.	Valmadrera, Como [5]	2,700	S	—
I.N.P.E.T.	La Spezia [6]	30,000	S	—
Industria Nazionale Oli Lubrificanti (NILO)	Milan	1,200	S	—
Lombardi Petroli	Villasanta, Milan	5,500	SC	—
Purfina Italiana S.p.a.	Genoa [7]	11,000	Comp.	1,500C
	Milan [8]	7,000	Comp.	—
	Rome [9]	10,000	Comp.	1,500C
	Florence	3,700	Comp.	—
Petroli d'Italia	Fiorenzuola d'Arda, Parma [10]	2,200	S	—
Raffineria Siciliana Oli Minerali (RASIOM)	Augusta, Sicily	35,000	S	—
Raffineria Oli Lubrificanti (ROL)	Viguzzolo, Alessandria [11]	1,400	SL	—
Socony-Vacuum	Naples [12]	60,000	Comp.	—
Sanquirico	Genoa	1,400	S	—
S.A.R.O.M.	Ravenna	12,000	S	—
S.A.R.P.O.M.	Trecate, Novara [13]	27,000	S	—
Italia	Cremona [14]	1,500	S	—
S.P.I.	Fornovo Taro, Parma [15]	2,200	S	—
STANIC	Bari [16]	33,900	SA	—
	Leghorn [17]	33,600	Comp.	—
S.T.O.I.	Florence [18]	3,350	S	—
Volpato	Milan	2,100	S	—

(1) 2,500 b/d Thermal Cracking capacity.
(2) Catalytic reformer under construction.
(3) Under construction: 4,800 b/d splitting plant. Scheduled completion: May 1956. 3,600 b/d cat. reformer, scheduled completion: December 1956.
(4) 7,600 b/d thermal reforming capacity. Under construction: 2,000 b/d Platformer. Scheduled completion: early 1956.
(5) 500 b/d cat. reforming capacity.
(6) 2,800 b/d thermal reforming capacity.
(7) 1,000 b/sd Platformer under construction.
(8) 3,000 b/sd vacuum distillation unit under construction.
(9) 500 b/d thermal reforming capacity.
(10) 900 b/d cat. reformer under construction. Scheduled completion: 7/31/55.
(11) Thermal reformer under construction.
(12) 16,000 thermal reforming capacity. Under construction: 22,000 b/d cat cracker.
(13) Under construction: 2,800 b/d cat cracker, 5,150 b/d vacuum unit, 315 b/d polymerization unit. Scheduled completion: Aug. 1955.
(14) 800 b/d cat. reforming capacity.
(15) 900 b/d cat. reformer under construction. Scheduled completion: July 31, 1955.
(16) 3,500 thermal reforming capacity. Under construction: 4,850 b/d additional crude capacity. Scheduled completion: Late 1955.
(17) 3,600 thermal reforming capacity. Under construction: 8,900 b/sd catformer. Scheduled completion: late 1955.
(18) 400 b/d cat cycloversion capacity. Under construction: 11,000 b/d crude capacity increase, 1,200 b/d cat. reforming capacity, 600 b/d thermal reformer.

NOTE: The following refineries are being built: AGIP refinery at Caligi, ISLOM at Gaeta, Sicily, and GOLFO refinery near Naples.

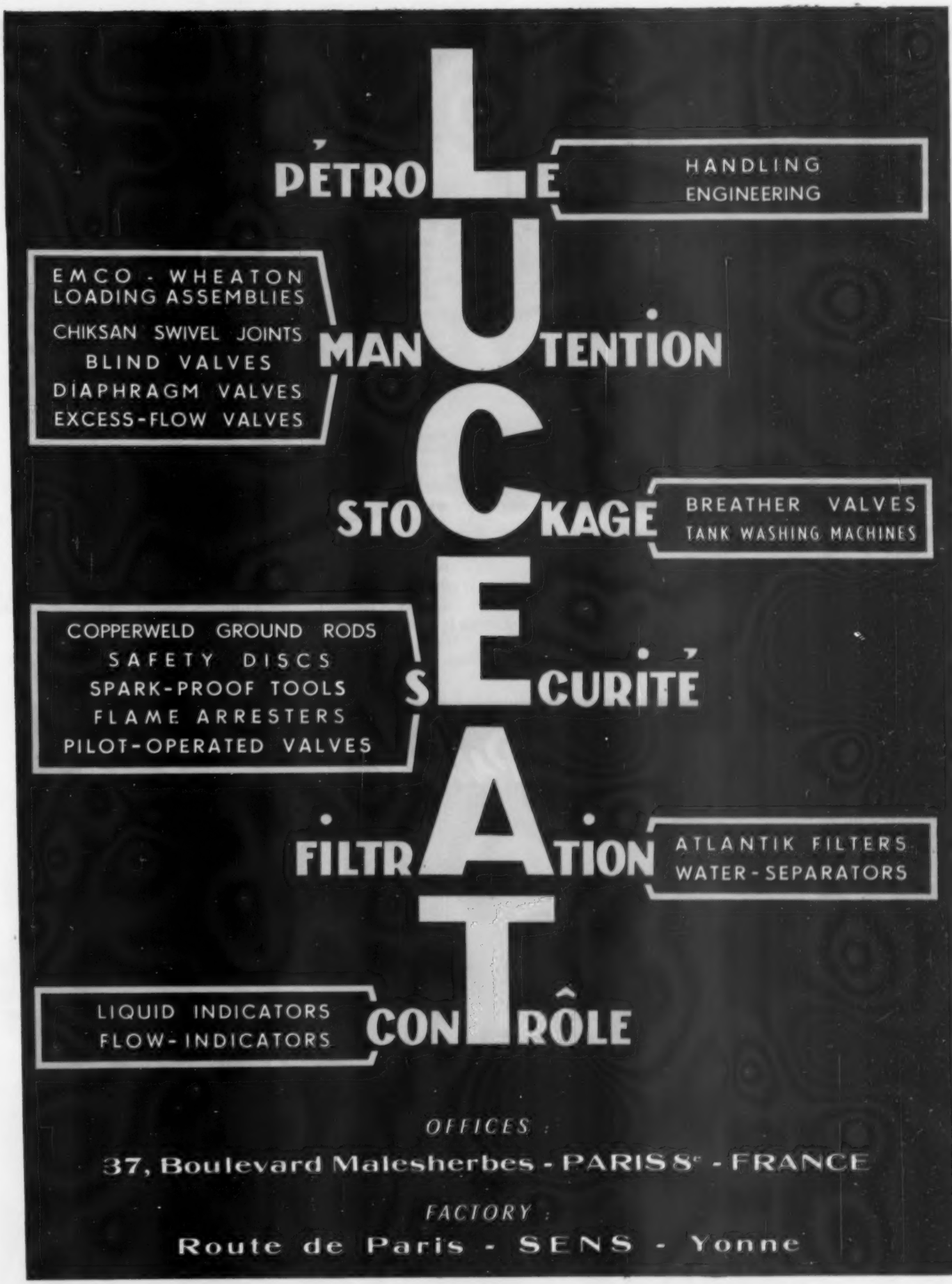
Japan:				
Daikyo Oil Co.	Yokkaichi	24,000	SLA	3,500C
Koa Oil Co.	Marifu [1]	10,000	Comp.	1,400T
Maruzen Oil Co.	Shimotsu	26,500	Comp.	3,500C
	Matsuyama	8,000	S	—
Mitsubishi Oil Co.	Kawasaki [2]	29,400	Comp.	3,000T
Nippon Mining Co.	Funakawa	6,000	Comp.	—
Nippon Oil Co.	Akita	4,000	SLAC	850T
	Kashiwasaki [3]	6,000	SLA	—
	Niigata	2,000	SLA	—
Nippon Pet. Ref. Co. Ltd.	Yokohama	20,000	Comp.	5,000C
	Kuadamatsu [4]	7,000	SLA	—
Showa Oil Co.	Kawasaki [5]	11,900	Comp.	1,200C
	Hirazaua	3,000	Comp.	—
	Niigata	9,700	Comp.	—
Toa Nenryo Kogyo Co.	Shimisu	7,000	SLA	—
	Wakayama [6]	40,000	Comp.	3,480T

(1) 1,200 b/d cat. reforming capacity.
(2) Wax treating and moulding plant under construction.
(3) Under construction: 6,000 b/d topping plant. Scheduled completion Nov. 1955. 600 b/d Platformer, 1,000 b/d Furfurl extraction plant. Scheduled completion: 1956 or 1957.
(4) 1,200 b/d cat. reforming capacity.
(5) 1,200 b/d thermal reforming capacity.
(6) 10,000 b/d cat cracker under construction.

Korea:
Plant destroyed.

Kuwait:				
Kuwait Oil Co. Ltd.	Mina al Ahmadi, Persian Gulf [1]	30,000	S	—

(1) 600 b/d bitumen plant under construction.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Name of Company	Plant Location	Crude Capacity	Type Plant	Cracking Capacity
Lebanon:				
Iraq Petroleum Co. Ltd.	Tripoli	11,250	S	—
Mediterranean Refining Co.	Sidon (1)	6,250	S	—

(1) Plant crude capacity being increased to 9,000 b/d.

Mexico:				
Petroleos Mexicanos	Arbol Grande, Tampico (1)	23,000	SLA	—
	Atzacapotzalco, D.F. (2)	62,000	SC	14,500T
	Ciudad Madero, Tampico (3)	78,000	SCA	6,500T
	Mata Redonda, Vera Cruz	17,000	SC	6,000T
	Minatitlan, Vera Cruz (4)	32,000	SL	—
	Poza Rica, Vera Cruz	4,500	S	—
	Reynosa, Tampico (5)	7,000	S	—
	Salamanca, Gto.	30,000	SCL	5,000T

(1) To improve refinery. Scheduled completion: late 1955.
(2) To increase capacity by 50,000 b/d. Scheduled completion: late 1955.
(3) Planning to increase capacity to 100,000 b/d and to install cat cracker and fluid coker. Scheduled completion: Early 1957.
(4) To install new pipe still, and thermal cat cracker. Scheduled completion: Late 1955.
(5) To increase capacity to 10,000 b/d and install thermal cat cracker. Scheduled completion: Late 1955.

Note: Pemex is planning to build a 30,000 b/d refinery on Pacific Coast.

Netherlands:				
N.V. de Bataafsche Petroleum Mij (Shell)	Pernis (1)	200,000	SCL	53,000TC
Caltex Petroleum Mij. N.V.	Pernis (2)	35,000	SC	6,000T

(1) 20,000 b/d thermal cracking capacity and 33,000 b/d cat cracking capacity.
(2) 6,500 b/d thermal reforming capacity. Under construction: 7,000 b/d Platformer and 4,000 b/d desulfurization unit. Scheduled completion 1957.

Netherlands West Indies:				
N.V. Curacaosche Petroleum Industrie Mij.	Curacao (1) Aruba (2)	200,000	Comp.	100,000T
Lago Oil & Transport Co.	Aruba (3)	440,000	Comp.	383,000TC

(1) 18,000 b/d thermal reforming capacity.
(2) Closed down.
(3) 340,000 thermal cracking capacity, 43,000 b/d cat cracking capacity and 16,000 b/d thermal reforming capacity.

Norway:				
A/S Norske Esso (A/S Ostlandske Petroleum-Compagni	Valloy per Tonsberg	2,000	S	—
Pakistan:				
Attock Oil Co.	Punjab, Rawahlpindi	5,000	S	1,500T
Peru:				
Cia. de Petroleo Ganzo Azul	Agua Caliente	1,200	S	—
Empresa Petrolera Fiscal	Iquites (1)	1,500	S	—
International Petroleum Co.	Talara	45,000	Comp.	14,000T

(1) Under construction.

Philippine Islands:				
Caltex (Philippines) Inc.	Batangas	13,000	SC	5,400C
Portugal:				
"Sacor" S.A. Concessionaria de Refinacao de Petroles em Portugal	Cabo Ruivo	27,000	SC	10,000C
Puerto Rico:				
Caribbean Refining Co.	San Juan	10,000		—
Commonwealth Oil Ref. Co.	Guayanilla Bay (1)	25,000		—

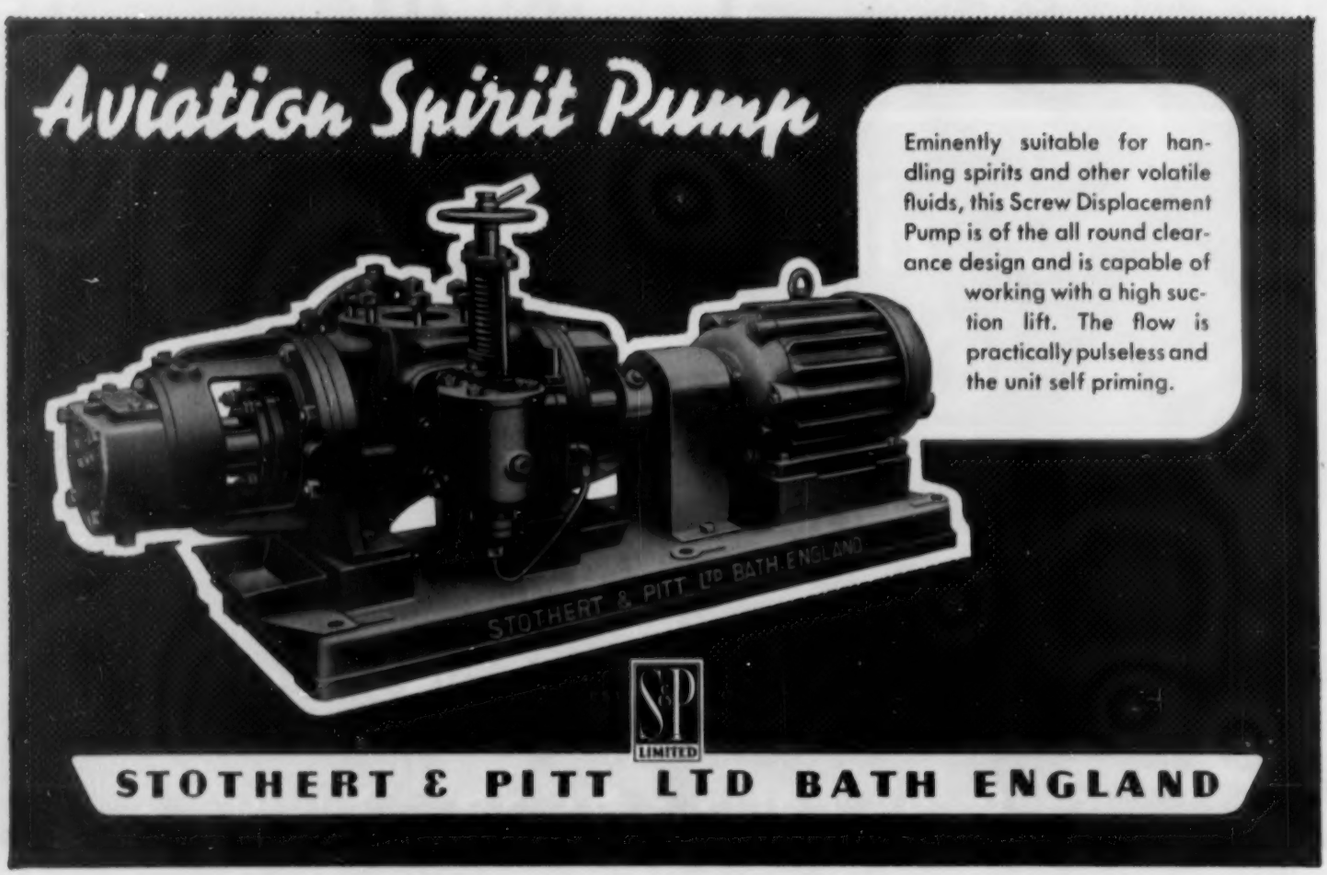
(1) Under construction.

Romania:

In the absence of official information, recent estimates indicate that Romania has daily refinery capacity of 210,000 barrels. The number of refineries in Romania is unknown.

Saudi Arabia:				
Arabian American Oil Co.	Ras Tanura (1)	189,000	SA	—

(1) 24,000 b/d thermal reforming capacity. Fluid Hydroformer with a 12,500 b/d capacity is under construction. Scheduled completion date: Jan. 1956.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Name of Company	Plant Location	Crude Capacity	Type Plant	Cracking Capacity
Poland:				
In the absence of official information, recent estimates indicate 1 refinery in operation in Poland with a daily capacity of 5,000 barrels.				
South Africa:				
So. Africa Torbanite Mining & Refining Co.	Boksburg N. Transvaal (1)	2,000	SAC	2,000T
Standard Vacuum Refining Co. of So. Africa Pty. Ltd.	Durban	15,600	SAC	5,700C
(1) Does not process crude petroleum.				
Spain:				
"Campsa" Cia Arrandetaria del Monopolio de Petroleo S.A.	Barcelona	250	SL	—
"Cepsa" Cia Espanola de Petroleo S.A.	Canary Islands (1)	30,000	Comp.	3,500T
Refineria de Petroles de Escombreras, S.A.	Escombreras (2)	30,000	SL	—
(1) Under construction: 10,000 b/sd distillation unit, 5,000 b/d Platforming capacity.				
(2) 8,500 b/d Thermal reforming capacity. Under construction: 23,000 topping plant, 8,000 Platformer. Scheduled completion: 1957. 4,500 b/d LPGas plant. Scheduled completion: Late 1955.				
Sweden:				
A-B Nymas Petroleum	Nynashamm (1)	12,000	Comp.	1,000C
	Malmo	1,900	SA	—
Koppartrans Oljeaktiebolag	Goteborg (2)	25,000	S	—
Svenska Skifferoje A/B	Narkes-Kvarntorp	2,000	S	—
(1) 1,900 b/d Thermal Reforming capacity.				
(2) 4,400 b/d Thermal Reforming capacity. Under construction: catalytic cracking unit. Scheduled completion: March 1956.				
Switzerland:				
Ipsa A.G.	Rotkreuz (1)	1,500	S	—
Schweiz-Sprengstoffabrick	Dottikon (2)	350	S	—
(1) Operates on tops.				
(2) Manufactures special naphthas.				
Trieste:				
Aquila S.A. Tecnico Industriale	Trieste	18,000	SCL	—
Esso Standard	San Saba	5,000	SLA	—
I.R.C.O.	Trieste	500	SA	—

Name of Company	Plant Location	Crude Capacity	Type Plant	Cracking Capacity
United Kingdom:				
British Petroleum Co. Ltd.	Isle of Grain, Kent (1)	90,000	SCL	12,500C
Berry Wiggins & Co. Ltd.	Kingsmouth on the Medway nr. Rochester, Kent.	4,300	S	—
	Salford	1,800	SLA	—
Briggs, & Co. Ltd., Wm.	Dundee, Scotland	1,000	SLA	—
Carless Capel & Leonard	London	200	S	—
Esso Petroleum Co. Ltd.	Fawley (2)	140,000	Comp.	36,000C
Lobitos Oil Fields Ltd.	Ellesmere Port (3)	4,000	Comp.	1,000T
London & Thameshaven Oil Wharves Ltd.	Thameshaven	2,000	LA	—
Manchester Oil Refinery Ltd.	Trafford Park	3,000	Comp.	—
National Oil Refineries Ltd.	Llandarcy S. Wales (4)	90,000	Comp.	12,500C
Scottish Oils Ltd.	Grangemouth	55,000	SC	12,500C
	Pumpherston, Scot.	3,500	SC	2,800T
Shell Refining & Marketing Co. Ltd.	Stanlow, Ellesmere Port (5)	91,000	Comp.	28,000C
	Ardrossan, Scot.	3,200	A	—
	Shell Haven, Essex (6)	66,000	SLAW	—
	Heysham, Lancs. (7)	36,000	S	—
Vacuum Oil Co. Ltd.	Coryton, Essex	22,000	Comp.	10,000C
(1) 5,000 b/d Platforming capacity.				
(2) 45,000 b/sd thermal reforming capacity. Under construction: 15,000 b/sd fluid hydroformer and 27,000 b/sd vacuum pipe still.				
(3) Platformer under construction.				
(4) 5,000 b/d Platforming capacity.				
(5) 9,200 b/d Thermal reforming capacity and 9,000 b/d cat reforming capacity. Epikote plant under construction. Scheduled completion end 1955.				
(6) 9,200 b/d thermal reforming capacity. Under construction: 12,000 b/d cat reformer. Scheduled completion: end of 1955.				
(7) 4,100 b/d thermal reforming capacity and 6,100 b/d visbreaking capacity.				
Turkey:				
Turkiye Petrolileri A.O.	Batman (1)	250	SA	—
(1) Under construction: Building 6,250 b/d refinery with 3,010 b/d cat cracker at Batman. Scheduled completion August 1955.				
U.S.S.R.				
It is estimated that crude capacity now approximates 1,350,000 barrels daily.				

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Name of Company	Plant Location	Crude Capacity	Type Plant	Cracking Capacity
Trinidad:				
The Texas Co. (1)	Brighton	5,000	S	—
Trinidad Leaseholds Ltd.	Point-a-Pierre (2)	85,000	Comp.	27,500TC
United British Oilfields of Trinidad Ltd.	Point Fortin	30,000	SA	—
(1) Formerly owned by Brighton Terminal Ltd.				
(2) 10,000 b/d thermal reforming capacity, 12,500 b/d thermal cracking capacity and 15,000 cat cracking capacity.				
Uruguay:				
Administration Nacional de Combustibles, Alcohol y Portland (ANCAP)	Montevideo	28,000	SCA	1,800T
Venezuela:				
Creole Petroleum Corp.	Amuay Bay (1)	140,000	S	—
	Caripito	70,000	SC	42,000T
Mene Grande Oil Co.	Oficina (2)	—		—
Phillips Oil Co.	Santa Ana (3)	2,300	Wax	—
Shell: Colon Development Co. Ltd.	Casigua	1,000	S	—
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	El Calvario	300	S	—
Compania Shell de Venezuela Ltd.	San Lorenzo	45,000	S	—
	Cardon (4)	145,000	Comp.	25,000T
Sinclair Oil & Refining Co.	Puerto La Cruz	35,000	S	—
Texas Petroleum Co.	Tucupita	10,000	S	—
Venezuela Gulf Refining Co.	Puerto La Cruz (5)	60,000	Comp.	9,500T
(1) 11,000 b/d Hydroforming capacity.				
(2) Closed Down.				
(3) To increase production 3,200,000 pounds per year.				
(4) 8,500 b/d thermal reforming capacity. Under construction: 35,000 b/d cat cracker. Scheduled Completion late 1957.				
(5) Design capacity still only 35,000 b/d				
Yugoslavia:				
Government:	Rijeka	7,000	SLAC	600T
	Sisak	10,000	S	—
	Bosanski Brod	2,800	SLC	500T

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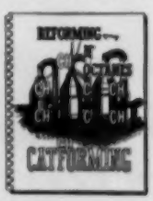

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The overall result of this all-in-one engineering is exceptional durability and performance. B-L refractory installations have established world records for continuous operation. For example, after initial runs of 785 and 610 days, B-L linings were in perfect shape—required no repairs during shutdowns.

Yes, from Regina to Saudi Arabia—and points in between—Bigelow-Liptak installations are setting new records for service and performance. For complete information write for the B-L catalog "One Source". Do it today!

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4070

Automatic Logging

(Continued from page 68)

converted to digital form and tabulated.

Automatic loggers are so arranged that a large number of readings may be taken simultaneously. Data is remembered until it can be printed by the electric typewriter even though several minutes may lapse between reading and tabulating.

Signals received by the logger are in electrical form. These are received by stepping switches which act as point scanners. The stepping switches feed input signals to the self-balancing potentiometer in a fixed sequence. The analog-to-digital converter geared to the output shaft of the potentiometer feeds digital data to the electric typewriter and to the punching mechanism. Once the data is recorded, the memory device is reset at zero to be ready for the next hourly readout or emergency printing.

Print cycles may be set for any interval of time. Often the data is recorded hourly. In any case the time is shown.

The automatic logger continues scanning input signals continously between printing cycles. No action is taken, however, unless the signals report values which are above or below "normal" tolerances. When high or low values are noted, the printing mechanism begins to function instantly. The time is noted and the abnormal value is printed, usually in red. Other values in the unit are also recorded. The emergency condition also may be reported to the operator by visual and audible alarm signals.

After making necessary corrections in operating conditions, the operator may obtain interim readings on the electric typewriter as often as required until process stability is achieved. This is done by merely pressing a button.

All signals received by point scanners are electrical. Measurements transmitted as 3 to 15 psi pneumatic signals are converted to electrical form. This is done within the logger which is provided with gasketed doors and connections for an air purge line. Doors of the cabinet are interlocked so that the equipment is automatically deenergized when the enclosure is opened. Equipment may be serviced between hourly readouts without loss of data because integrators meet hazardous area requirements.

Manufacturers of automatic loggers believe that the equipment will not be made obsolete by the development of new control or other instruments. Conversion from pneumatic to electronic control systems will have no effect on logger operation.

Reliability and maintenance costs are said to be comparable with other instrumentation devices. Specialists are not required. Stepping switches are built with a life expectancy of 30 years. The analog-to-digital converter has an anticipated useful life of five years before replacement. Worn gears may be replaced readily without loss of accuracy. Many components are those found in conventional instruments.

As insurance for continuous operation under any conditions, it is possible to install duplicate potentiometers, digital converters and electric typewriters without adding greatly to investment in the system. A second typewriter permits continuous recording of conditions at critical points during emergencies. Reports can be typed at intervals of only a few seconds, thus assisting the operator in obtaining a more accurate trend analysis than is possible with conventional analog instrumentation.

The Petrofina automatic logger is being built by Fisher and Porter Co. and will be ready for installation in November. The 126-foot graphic panel on which all nine units will be represented is being installed by Panellit, Inc.

•

REFERENCES

"An Information System Consolidates Process Control," by Albert F. Sperry, president, Panellit, Inc., *Automatic Control*, November 1954.

"Automatic Intelligence Gathering Systems," by Robert K. Stern, manager, Data Reduction and Automation Division, Fischer & Porter Co., *Instrument Society of America Journal*, Vol. 2, No. 5, May 1955.

"Canada's Newest Refinery," by P. de Haulleville, engineer, Canadian Petrofina, *World Petroleum*, Vol. 26, No. 5, May 1955.

Oilman R. E. Smith of Houston was named Chief of the Roughneck's Club for 1955 in ceremonies held recently at Lone Star Steel Company's integrated steel mill in Northeast Texas. Above, Mr. Smith, right, receives a handsome plaque and jeweled lapel emblem from E. B. Germany, Lone Star president. The Roughneck's Club is dedicated to the recognition "of the pioneers of yesterday and today whose perseverance and courage have made our nation the world's leader in petroleum," Mr. Germany explained. The meeting at the Lone Star plant was attended by more than 400 oil men who inspected the huge mill and its facilities for making oil country tubing, casing and line pipe.

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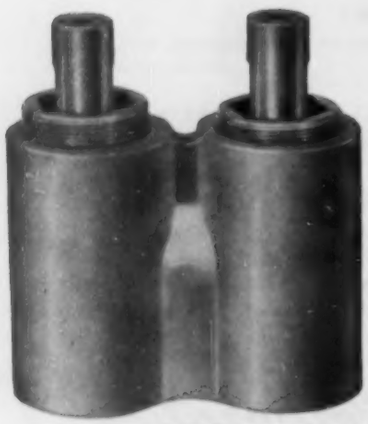

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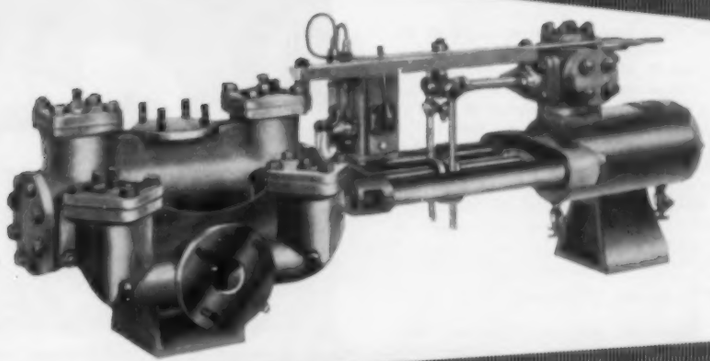

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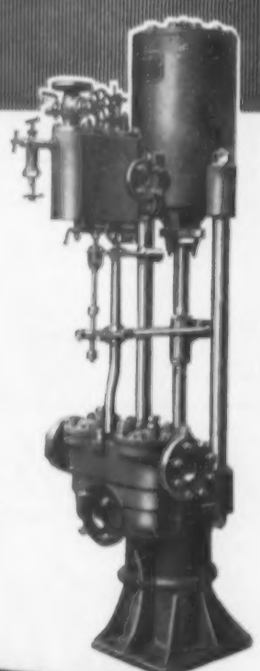
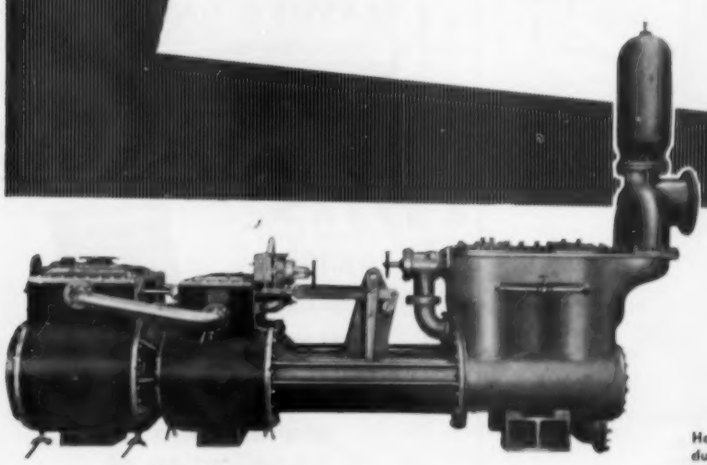
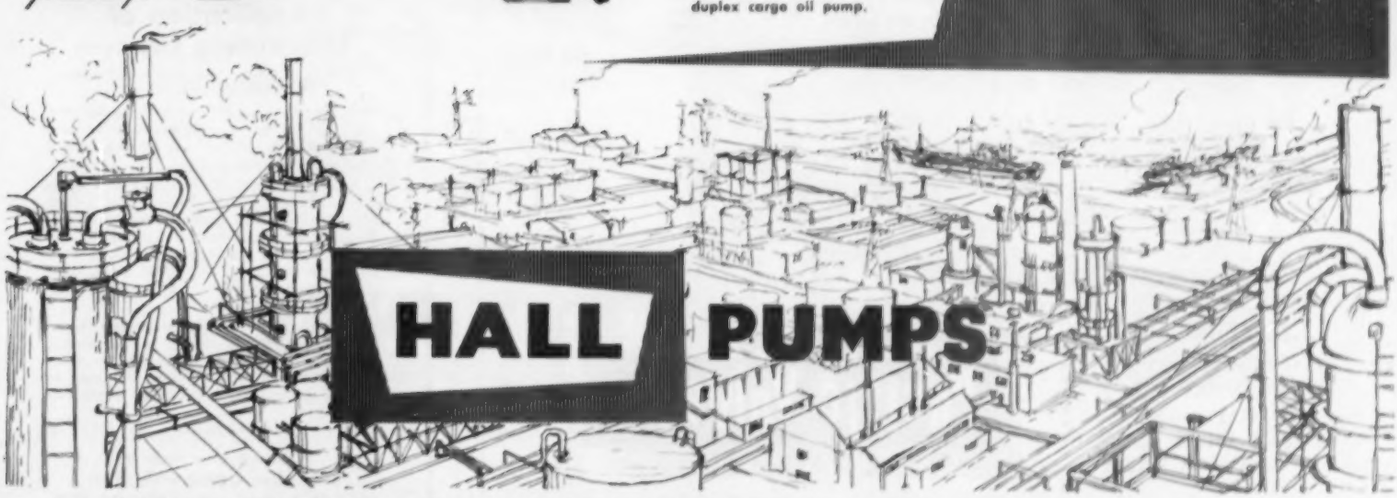


Single cylinder direct acting feed pump.



Horizontal compound duplex cargo oil pump.



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James E. Pew

James E. Pew, 54, a director and manager of the natural gas and natural gasoline division of Sun Oil Co., died June 20 of a coronary occlusion. An authority on natural gas, he was director of the natural gas and natural gasoline division of the Petroleum Administration for War during World War II. In the past ten years he directed a $30 million expansion of Sun's natural gas processing facilities.

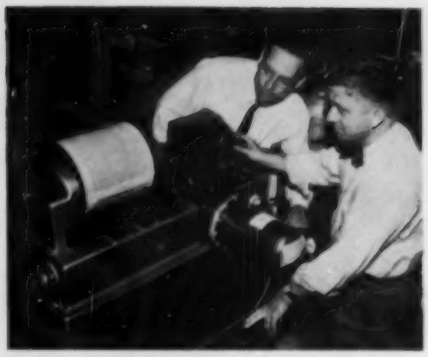
Mr. Pew was a son of the late John G. Pew, for many years president of Sun Shipbuilding & Dry Dock Co. He was a grandnephew of the founder of Sun Oil Co.

GM Show Planned

An outdoor exposition portraying the contributions of diesel and aircraft power to America's industrial economy will be staged by General Motors on Chicago's lakefront August 31 through September 25. The show will be open to the public in a 1,000,000-square foot area on South Lake Shore Drive, adjacent to Soldier Field. This was the site of the Century of Progress exposition in 1933-34.

Electrical Impulse Contactor

A new electrical impulse contactor that can activate open-close electrical circuits at varying rates up to 1,500 times per minute to actuate electronic and electromagnetic counters, pre-determining counters, totalizers, recording printers, sampling devices and devices for injecting additives, has been introduced by Rockwell Manufacturing Co.



Pictured above is the hydrocarbon recorder developed under the auspices of the Air Pollution Foundation at the Truesdall Laboratories, Los Angeles. The adapter recorder measures the air's hydrocarbon content in an automatic and continuous operation. Special filters take out the water content, carbon dioxide and miscellaneous dirt and dust. Dr. Nicholas A. Renzetti (right), senior physicist of the foundation, is seen inspecting the device with Dr. Lewis H. Rogers, senior chemist.

Remote Drilling Recorder

The Martin-Decker Corp. is currently using a newly-developed remote electric drilling recorder. A well drilling near Martin-Decker's Long Beach plant is wired to the indicator-recorder located in one of the company's executive offices. The instrument makes a complete log of the rig status, recording such data as the number of round trips, time on bottom, whether the string is going into or coming out of the hole, etc.

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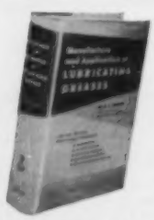

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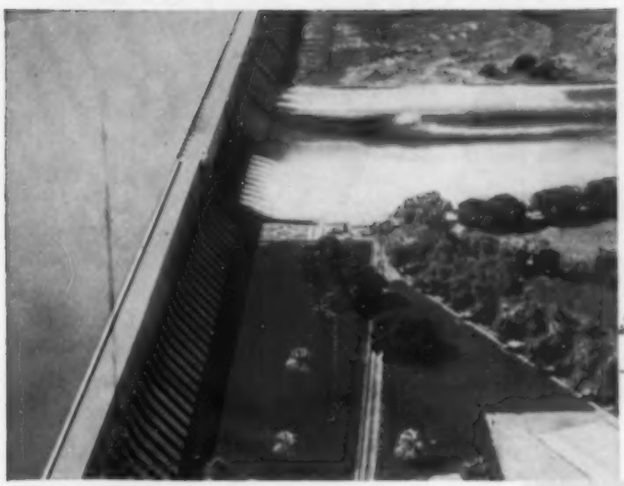

EGYPT — For more than half a century, the Nile's gigantic Asswan Dam has been the key point in Egypt's vast irrigation system. Now, engineers are installing a powerful hydroelectric plant in this dam. Cheap electricity from the plant will aid agriculture and heavy industry . . . will benefit all Egypt. Caltex lubricants and fuels are used for all construction equipment in this new project to harness the power of the Nile.

DENMARK — Motorists in and around Copenhagen — colorful capital of this gracious land — are familiar with spotless Caltex service stations. Here, as in 67 countries throughout the Eastern Hemisphere, the gleaming Caltex banjo sign stands for the finest automotive products, service that saves maintenance costs and the courtesy that every motorist has a right to expect.

PHILIPPINES — Gaily bedecked with pennants, the "s.s. Caltex Manila" stands by to deliver the first shipment of crude oil to the new Caltex Philippines refinery at Batangas. Officially opened in December, 1954, this modern refinery will provide work for many Filipinos and will help answer growing demands for petroleum products for agriculture, industry and automotive transport.

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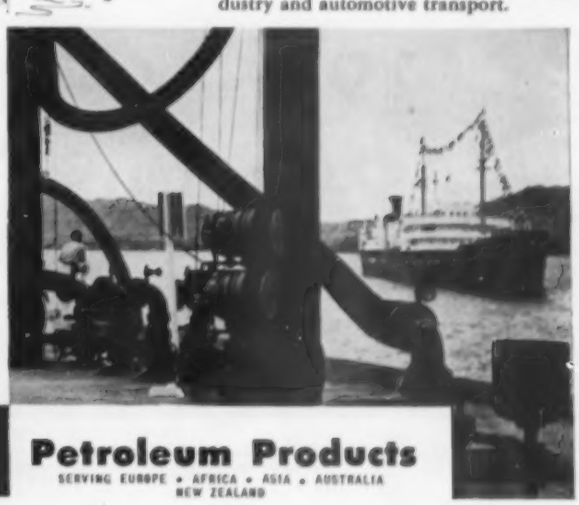

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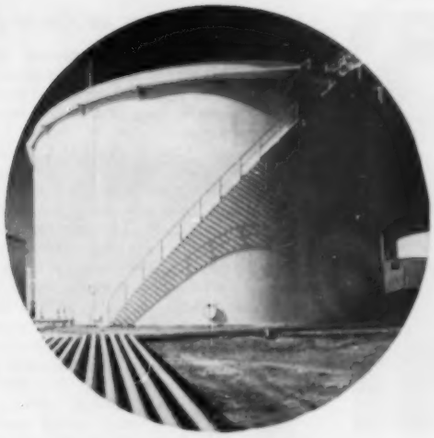

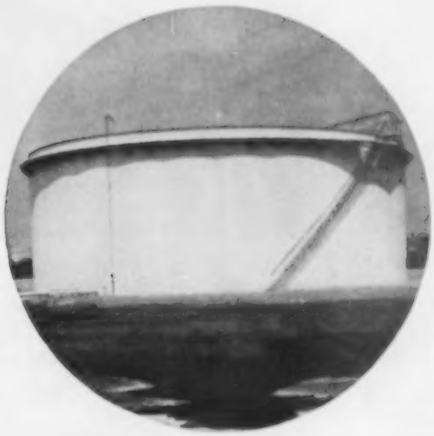

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By GENERAL AMERICAN

The Wiggins roof floats on the surface of a stored product and the triple seal protection turns practically all pumping and standing losses into savings. Simple design keeps maintenance low. Tested and approved under all weather conditions.

Only the Wiggins Floating Roof has all the specifications which 30 years' experience has proven necessary for best performance.

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P.O. Box 19, Keelung, Taiwan (Formosa)

Guatemala Plans New Petroleum Law

Following the overthrow of a communistic-slanted regime in Guatemala, the new administration headed by President Carlos Castillo Armas is planning a completely revised law which will permit exploration for petroleum by private capital. A government commission with Roy Merrick, an American oil expert, as advisor is working on a legislative measure, reported to be similar to laws recently enacted by Peru and Turkey, which is expected to receive Congressional approval in August of this year.

As presently drafted, the law calls for the limitation of concession holdings by any one company to 1,438 acres; a minimum investment per hectare annually; and a royalty of 12½ percent payable in oil if the government so elects. Although all oil is the property of the company, a 50 percent tax is imposed on net income from oil from which all other tax payments may be deducted. The law provides a 27½ percent depletion allowance up to one half the net investment.

Interest in Guatemalan oil prospecting is directed to the province of Peten, an isolated, thinly populated jungle area bounded by Mexico and British Honduras. A partial magnetomer aerial survey made some years ago indicated some favorable structures and oil seepages have been reported from various points in the region. Parts of Peten are relatively near fields in southern Mexico, but no conclusive indication of oil in commercial quantities has been found and it remains wholly a region for wildcatting. Several international companies and a few smaller ones have indicated an interest in exploration in the region once a more liberal petroleum law is enacted.

New Look for BP Tanker Fleet

The BP shield, symbol of the world-wide organization of The British Petroleum Co., is being fitted to the funnels of the 150 tankers owned by the British Tanker Co., British Petroleum's shipping organization. The ships are also flying a re-designed house flag.

The President of the Turkish Petroleum Administration, Emin Iplikci, giving Petroleum Research permit No. 10 to Celalettin D. Bukey, general agent of the Gilliland Oil Corp. in Turkey. Drilling is expected to be undertaken this fall following issuance of licenses covering areas selected from the permit.

German Processes Pact Signed

An agreement which will permit Arthur G. McKee & Co., Cleveland, to use a number of important German chemical processes in plant construction in the United States, its territories, and in Canada has been consumated between the company and The Uhde Corp. of New York, a subsidiary of Friedrich Uhde, GmbH, of Dortmund, Germany.

The processes cover a wide range in the inorganic chemical field and include the entire fertilizer field. Many of the products are basic raw materials which are used in the manufacture of other chemicals. These German processes heretofore have not been widely available to U. S. builders of chemical plants.

Exploration in Central America

International oil companies are showing renewed interest in oil exploration in Central America although as yet no commercial production has been established in any of the five countries comprised in that area.

In Costa Rica, Union Oil Company of California, through its subsidiary, Campania Petrolera de Costa Rica, is carrying out a drilling program in the south near the border of Panama, along the Caribbean coast. One test, started last year, was abandoned in January at about 7,000 feet. A second test, about a mile distant on the same structure, was carried to about the same depth without results. A third well is planned, about 40 miles from these tests, and an access road through the jungle to the site is under construction.

The oil company's concession from the Costa Rican government calls for the drilling of at least three wells. Union officials state that the formation now being tested extends across the border into Panama and that plans for the future contemplate extending the search to that area.

Gulf Oil Corp., through its subsidiary, Bahamas Exploration Co., has been active for some time in British Honduras, where it holds a concession for exploration in the northern part of that country. Survey results led to the shipment to Belize of drilling machinery for field tests now under way.

New Sun Affiliate

H. R. Swisher, marketing accounting department manager, Sun Oil Co., and R. F. Blewett, managing director of Belgian Sun Oil Co., a subsidiary, have been named to the board of directors of a new Sun Oil affiliate, Sun Oil Svenska Aktiebolag (Swedish Sun Oil Co.). Operations of the new company began June 1. Formed to extend the retail distribution of Sun's branded products in Sweden, the company has E. Praestrud-Olsen, present Sunoco distributor, as chairman of the board. Carl-Eric Tornheden is managing director of the Swedish company.

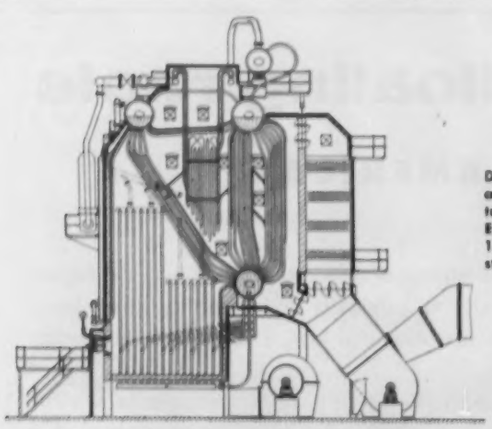
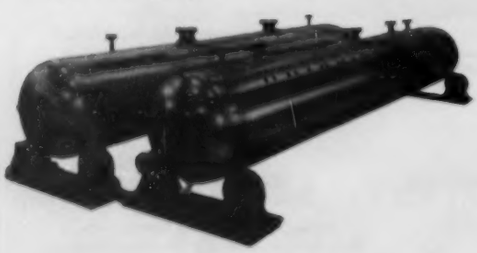


Diagram shows an oil fired water tube boiler. Evaporation 175,000 lb. of steam per hour.

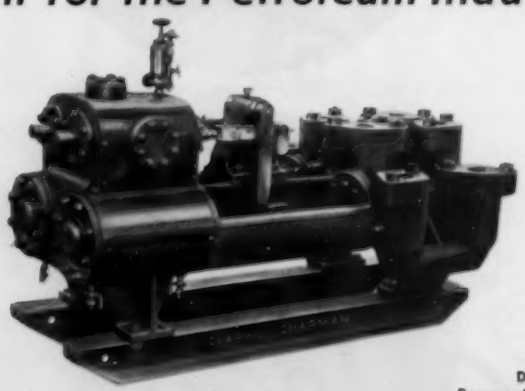
- Water Tube Boilers
- Fusion Welded Pressure Vessels
- Lifting and Haulage Gear
- Pumping Machinery
- Flameproof Lighting Fittings

Clarke Chapman

Fusion welded boiler drums to Class 1 requirements of Lloyds Register of Shipping.



Equipment for the Petroleum Industry



Horizontal Duplex High Pressure Feed Pump.

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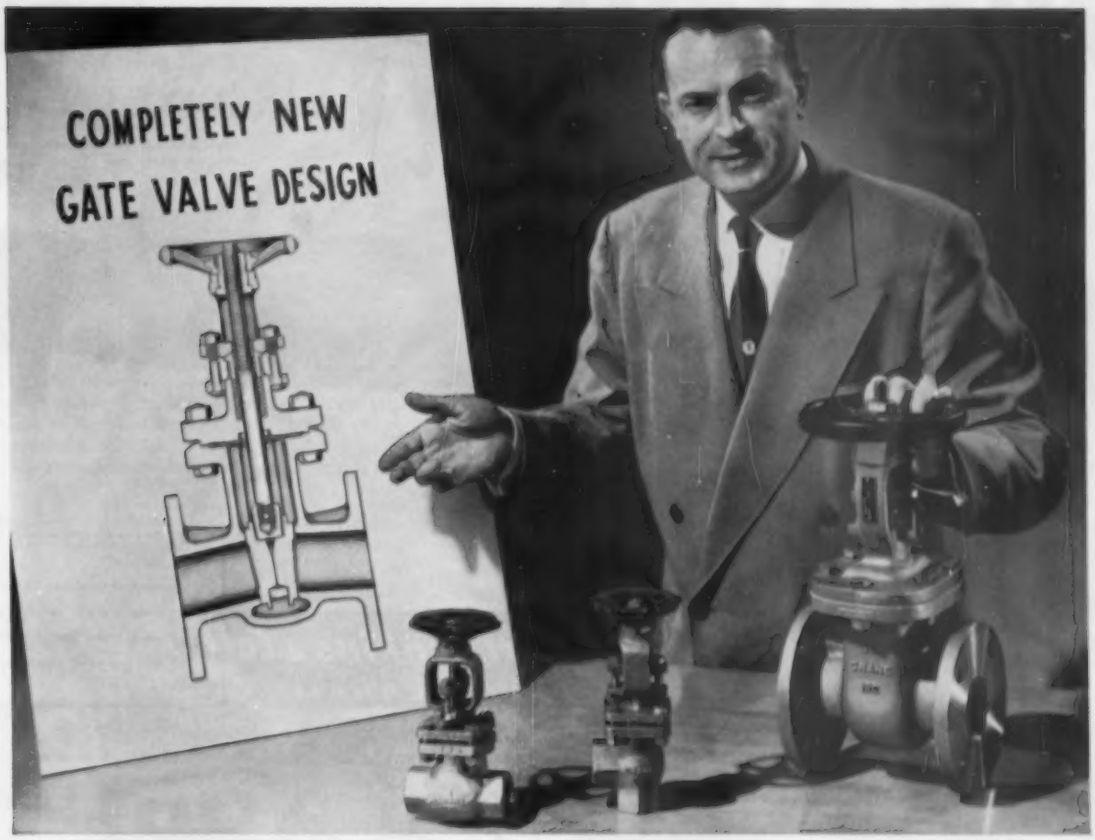


New CRANE Corrosion-resistant valves in 18-8 SMo and Craneloy 20

Gate, Globe, Angle and Check Patterns

Few valves for process industries have ever received the quality treatment given this new Crane line—at prices you'll find O.K.

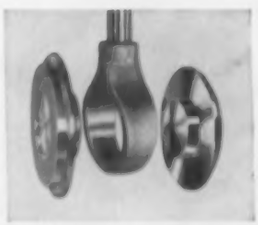
Note, for instance, the unique yet simple split-wedge disc construction in the gate valves. Those dual identical discs are free to rotate in their holder—the most effective design for resisting galling. The trunnion shape at the back of each disc assures even distribution of closing forces. You couldn't buckle them if you tried.

The globe and angle valves give equally outstanding control of corrosive fluids. A new type disc-stem connection, with minimum clearances, practically eliminates vibration. By placing seating load closer to seats, it provides easier, more accurate closure.

Check valves feature compact, thoroughly proved, non-slamming design.

Throughout, these valves are built for better service in your choice of Crane 18-8 SMo Stainless Steel or Craneloy 20. Both lines come with screwed or flanged ends.

ASK FOR THIS CATALOG—Full information including service suggestions given in circular AD-2080—available from your Crane Representative or by mail. Crane Co., General Offices: Chicago 5, Ill. Branches and Wholesalers everywhere.



New split-wedge disc in gate valves combines the benefits of free rotation with uniform seat load pressure.

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Jenkins of ROTHERHAM

Welded

★ Mild steel atmospheric column, 54'0" high x 5'0" dia., ⅝" shell, 9/16" ends, with internal trays. Designed and constructed in accordance with API-ASME Code. Tested 200 lbs. per sq. inch hydraulic.

The Ivanhoe trademark identifies the craftsmanship and dependability of Jenkins-welded equipment. Pipe work, tanks, atmospheric and fractionating columns, condensers, pressure vessels, are typical examples of the fabricated welded work we are producing to Class 1 standard.

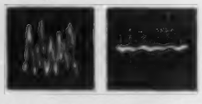
Robert Jenkins & Co Ltd.
ESTABLISHED 1856
ROTHERHAM

Our new catalogue "Welded Fabrications" details our organization and facilities. May we send you a copy?

Telephone: 4201-6 (6 lines)

Stop pulsation . . .

Pipes carrying gas and air under pressure from pumps, blowers, or compressors may fail, or require special reinforcement, as a result of surging and the consequent pulsatory vibration. This problem is overcome by fitting BURGESS Snubbers, which convert intermittent flow to smooth flow—and which, by eliminating a cause of line failure, often effect economies by permitting less costly pipes to be used. BURGESS Snubbers are made to the specifications and design of the original American BURGESS-MANNING patents.



Oscilloscope recording shows pulsation (left) and smooth flow attained after fitting BURGESS Snubber (right).

BURGESS *Pulsation Snubbers*

Designed by BURGESS-MANNING, DALLAS, TEXAS · Manufactured by BURGESS PRODUCTS CO. LTD., ACOUSTICAL DIVISION, HINCKLEY, ENGLAND.

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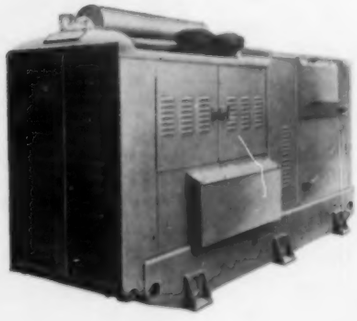
ENGINES AND GEARBOXES for Industrial Application

Meadows manufacture a complete range of diesel, petrol and natural gas engines and generators for industrial applications. The power mules and alternator sets have been designed to meet the need for a compact and easily transportable source of power for air compressors, welding sets, generating sets, dumpers, earth-moving equipment, fork lift trucks, pumps, cranes, road making and building equipment and stone crushers—to mention but a few.

Meadows' engineers will gladly help to solve your power problem and supply information on application.

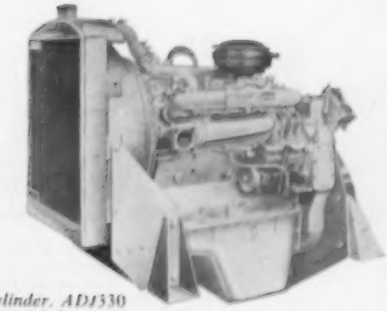
A Meadows 4DJ420 Power Plant driving a Lufkin Balancine



95 kW Generating Set incorporating the 6DJ970 6-cylinder engine, 150 mm. bore x 150 mm. stroke.

4DJ420 Power Mule
130 mm. bore x 130 mm. stroke 4 cylinder engine. 66 B.H.P. at 1600 r.p.m.

6GJ630 Self Contained Power Mule
6 Cylinder 130 mm. bore x 130 mm. stroke natural gas engine. 100 B.H.P. at 1600 r.p.m.



4-cylinder, ADJ330 Industrial Engine
120 mm. bore x 120 mm. stroke. 65 B.H.P. at 1800 r.p.m.

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INDUSTRIAL DIVISION

FALLINGS PARK, WOLVERHAMPTON

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Oil Story Simply Told

The Story of Petroleum, a new booklet explaining the complex operation of the oil industry in clear, simple language aimed at the junior school student, has been published by Shell Oil Co.

The booklet tells how exploration crews hunt oil, how drilling crews sink wells, how pipe liners move oil to refineries, how chemists and engineers refine crude oil to make products, and how thousands of people in the distribution end of the industry move the products from refineries to service stations, factories, homes and other places where oil is used.

The booklet is available without cost from Shell Oil Co., 50 West 50th St., New York City 20.

Techno Instrument Appoints Hill & Christopher

Glenn Grosjean, general manager of Techno Instrument Co., has announced the appointment of Hill & Christopher advertising agency in Los Angeles to direct the company's advertising and sales promotion.

The Techno Co. manufactures the magnetic mirragraph system for seismic surveys. New models feature a hand-portable, completely integrated system.

Speeds Oil Canning

George Radich, a veteran Shell Oil Co. mechanic, has invented a device which has permitted a substantial increase in canned motor oil production at Shell's Sewaren, N.J., canning plant. According to Shell engineers, it may lead to a minor revolution in the canning industry. The device is a simply-constructed turntable that permits unloading cans from two cars into a single conveyor eliminating canning machine interruptions.

Secondary Recovery Bulletin

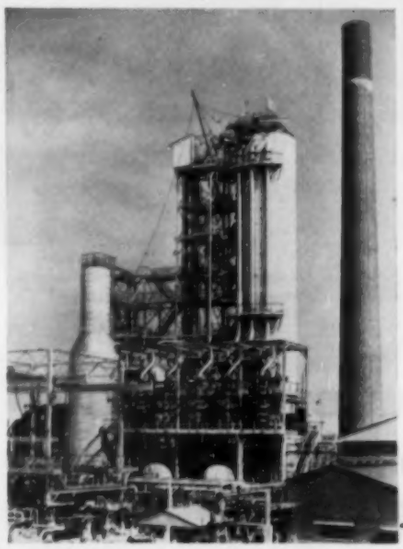
The Interstate Oil Compact Commission announces the publication of "Secondary Recovery Operations in Kansas During 1953," prepared by the Kansas Secondary Recovery Committee. This report is a reprint from Bulletin 107, State Geological Survey of Kansas, 1954. Copies may be obtained from the headquarters office of the Interstate Oil Compact Commission, Box 3127, Oklahoma City 5, Okla.

Grangemouth Power Station, British Petroleum Co., Ltd. Architects: Messrs. Farmer & Dark.

Oil Harbour and Port Installations, British Petroleum Co., Ltd. New Aden Refinery. Consulting Engineers: Messrs. Rendel, Palmer & Tritton.

THE WIMPEY ORGANISATION

has successfully carried out every aspect of work connected with oilfield development, refineries and oil port installation at home and overseas.



Topping Unit, British Petroleum Kent Refinery. Managing Contractors: E. B. Badger & Sons, Ltd. Mechanical and Electrical Contractors: George Wimpey & Co., Limited.

Marine Drilling Platform for Shell at Qatar.

Contractors to:—

British Petroleum Company
Anglo-Saxon Petroleum Company
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GEORGE WIMPEY & CO. LIMITED, HAMMERSMITH GROVE, LONDON, W.6

In the foreground is the 8,000-barrel-per-day catalytic reformer of the Atlantic Refining Company at Port Arthur, Texas, designed and built by The H. K. Ferguson Company.

PROCESS CONTROL...by ELECTRONICS

design and installation of the first large refining unit having all-electronic controls

THE H·K·FERGUSON COMPANY ENGINEERS AND BUILDERS

Engineers of The H. K. Ferguson Company applied their extensive experience in automatic process control systems—experience gained in the design of all types of chemical and petrochemical plants—to help create this modern, efficient reforming unit.

Write for detailed information on how Ferguson's one-contract, one-responsibility service can supply your engineering and construction needs.

THE H. K. FERGUSON COMPANY
Ferguson Building • Cleveland 14, Ohio
Subsidiary of Morrison-Knudsen Company, Inc., world-wide construction contracting organization, of Boise, Idaho

OFFICES: New York • Cincinnati • CLEVELAND • Chicago • Los Angeles • San Francisco

ASSOCIATED COMPANIES: H. K. Ferguson Company of Canada Limited; H. K. Ferguson Company of Great Britain Limited; H. K. Ferguson de Mexico, S. A. de C. V.; H. K. Ferguson of Panama, Inc.

HUDSON Solo-aire and Combin-aire COOLING UNITS

minimize water consumption in the Pegasus Plant of Magnolia Petroleum Company, Midland County, West Texas

Pictured in the foreground is the HUDSON Combin-aire unit, with Solo-aire units in the background. Air is used directly for cooling in the Solo-aires where low temperatures are not required. The Combin-aire uses a small quantity of water to precool the air so that entering hot fluids may be cooled to effluent temperatures lower than those obtainable by direct use of air.

If the total heat load of this plant had been dissipated thru a conventional cooling tower, 158 million gallons of water per year would have been required for makeup. The actual annual water makeup for the plant is only 17 million gallons per year. In this plant the use of the Solo-aire and Combin-aire have proven advantageous, resulting in savings in first cost, in operating costs for horsepower, water treating, and maintenance, and in obviating necessity for drilling of several water wells. Savings in cost of piping result thru installing the Combin-aire in close proximity to process equipment, made possible because the effluent high temperature air is always undersaturated with water vapor and nuisance and high maintenance cost due to water carryover or condensation are eliminated.

New bulletin
"Cooling with Air"
mailed upon request

HUDSON
ENGINEERING CORPORATION

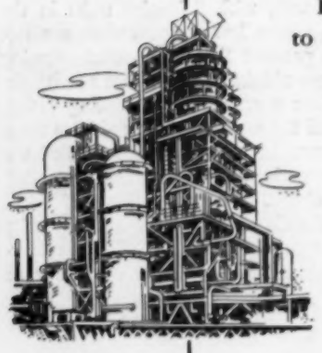
FAIRVIEW STATION • HOUSTON, TEXAS

STABILITY

It is Wyatt's policy to maintain financial structure to match its plant structure. This surplus item in the assets column is in reality just another working tool.

As processing equipment becomes larger and more intricate, Wyatt's plants must be enlarged and fitted to meet their obligation. That is when a surplus ceases to be cash on hand and goes to work itself.

Putting some of the profit back in the business also gives a lift to employment, since men go to work as dollars go to work.



Wyatt's

HOUSTON-DALLAS-NEW YORK-TULSA

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